Investigation of a Broken Eyebolt in Industrial Building 2

TD-07-010

J. Blowers, T. Arkan, T. Beale, D. Gaw, D. Harding, G. Kobliska, S. Makarov, R. Ruthe, I. Samayavong, E. Schaffer, M. Schmidt, D. Smith, R. Sood, J. Zweibohmer

Introduction

On 19-May-2007 an eyebolt broke while it was being installed into a Booster Multipole magnet in Industrial Building 2 (it did not break while in use). The bolt was being screwed in by hand using a small wrench inserted into the eye hole for leverage. This bolt was part of the lifting mechanism for the magnet, and so there was concern that there was a defect with the bolt. As such, this investigation was treated as a suspect/counterfeit investigation.

Conclusions

The conclusion is that the bolt broke due to over torquing. The bolt was over-torqued because epoxy had leaked into the insert into which the bolt was being installed, which caused the bolt to go in with some difficulty. As such we are 100% confident that this bolt was not a counterfeit.

Detailed Description of the Event

A Booster Multipole magnet (series designation BMA) weighs approximately 500 pounds when fully assembled. The lifting design called for four eye bolts installed in the horizontal position into key inserts embedded in the G10 feet. The magnet was epoxy impregnated, and it appeared that some of the epoxy leaked into the key insert in which the bolt was being installed. The technician used a small wrench for leverage (it was placed in the eye of the bolt) and was screwing the bolt in by hand. He described that the bolt continued to become tighter as he installed it, and that it tore before the shoulder was seated. This was the second bolt being installed on this magnet, and the first one went in with no problem. This was the first time this particular technician had installed these bolts. After cleaning out the key insert the replacement bolt went in without any problem.

Timeline

Here is a timeline of the activities related to this investigation. Details of some of these events are described in other sections of this report.

13-Apr-07: lifting design questioned
16-Apr-07: calculation of safety factor completed
25-Apr-07: load test completed using bolts from stockroom
25-Apr-07: eye bolts purchased from McMaster-Carr first issued to magnet BMA004
03-May-07: engineering approval given for using eye bolts in horizontal position
08-May-07: decision made to purchase swivel bolts to replace the eye bolts
10-May-07: swivel bolts purchased
15-May-07: swivel bolts first issued to production; use of them was not a requirement
19-May-07: eye bolt broke
21-May-07: Magnet Systems Department management informed of the event; all eyebolts used for lifting the magnets were removed from production; use of swivel bolts was made a requirement

22-May-07: Directorate confirmed this should be treated as suspect/counterfeit; investigation into part traceability initiated; parts in IB4 inventory were tagged to prevent issuing
23-May-07: Part traceability investigation completed
24-May-07: Manufacturer confirms that the bolt is theirs
25-May-07: Outside laboratory determines the bolt broke from overtorquing
01-Jun-07: MSD personnel performed load and torquing tests

Paths of the Investigation
In an effort to determine the cause of the bolt failure, a number of "branches" of the investigation were performed. These included part history (i.e. traceability), manufacturer/distributor analysis, third-party analysis and internal testing. Other related topics which were also reviewed included control of designs and the system used to determine the safety of the lifting system design.

Part traceability:
In an effort to determine the history of the bolt, and to determine the scope of its use, we reviewed all the records related to the bolts in question. The bolt was called out in the Bill of Material on assembly drawing 5520-ME-445004, and the design of the eyebolt was specified on drawing 5520-MA-393841. The bolt was not required to be certified. The parts were purchased from McMaster-Carr on ProCard order number PRN91400. They were received at Industrial Building 4 on 26-Apr-07, and assigned Routing Form number 86210. They were issued via Parts Kits and Additional Parts Requests for use in magnets BMA002 through BMA012. Appendix I contains all the records.

Distributor/Manufacturer Analysis:
We contacted McMaster-Carr on 23-May-07 to inform them about the broken bolt. They were very responsive to this issue, and worked with us to resolve it as quickly as possible. They spoke very highly of the bolt manufacturer Chicago Hardware, and stated that CH does not import anything and that there have been no reported incidences or returns of this particular bolt. During a subsequent conversation it was also reported that this particular bolt had over 19000 transactions last year, and 4400 units have been sold so far this year through McMaster-Carr.

We sent them pictures of the broken bolt and of two other bolts with different markings (see appendix II). Chicago Hardware, the manufacturer, confirmed that both bolt designs are theirs (see appendix III). The difference between the two designs is the era in which they were forged; the design was changed about 10 years ago.

Both McMaster-Carr and Chicago Hardware are interested in looking at the broken bolt, and so it will be sent to them. The results of their studies will eventually be incorporated into this report.

Third-party Laboratory Analysis:
The broken bolt was taken to a local testing laboratory on 23-May-07. They confirmed on 25-May-07 that the bolt broke due to over-torquing, not due to any material or forging defect (see appendix IV).

Internal Analysis:
Based on the report from Materials Engineering, Inc., we ran tests to confirm the torque required to break the bolt. Four bolts were tested, and these are the results:

#1: FNAL stock room ("old" forging) broke at 30 ft-lbs
#2: FNAL stock room ("new" forging) broke at 42 ft-lbs
#3: McMaster-Carr broke at 40 ft-lbs
#4: McMaster-Carr broke at 40 ft-lbs

It is believed that this torque could have been achieved by hand with a small wrench. It is also worth noting that the recommended torque for SAE Grade 5, 3/8"-16 bolts is 30 ft-lbs. The recommended torque for a Grade 8 is 45 ft-lbs. It is believed that these forged bolts are somewhere between Grade 5 and 8.

In addition to the torque testing, we also ran a test with an Instron to determine how much load a single bolt could handle when properly seated and in the horizontal position. The bolt began to show plastic deformation around 1500 pounds, and then yielded at 2150 pounds (see appendix V for details of the test).

Design Control:
The original assembly drawing called for a half-inch bolt 5520-MA-393720. This part subsequently appeared on the initial Parts Kits, and when the Kits were filled the Routing Form number for 393720 was recorded on them. The calling of 393720 on the BOM was a mistake, and it was corrected on Engineering Change Order 8680 which took the assembly drawing to revision C. When the mistake was identified, the Parts Kits were hand-changed by crossing out 393720 and writing in 393841. Unfortunately the Routing Form number was not changed at the same time, and so the records contributed to some confusion during the initial part of the investigation.

It was concluded that the appropriate design controls were in place and used effectively, and that we need to pay close attention to making hand-written changed to ensure that all the appropriate information is updated.

The Use of Eyebolts in the Horizontal Position:
It is universally agreed that using eyebolts at an angle greatly reduces their working load limit, and so should be avoided whenever possible. In this situation it was determined by our engineers, through calculations and a load test, that using them in the horizontal position was 100% safe, and was deemed to be safer than using them in the standard vertical position (see appendix VI).

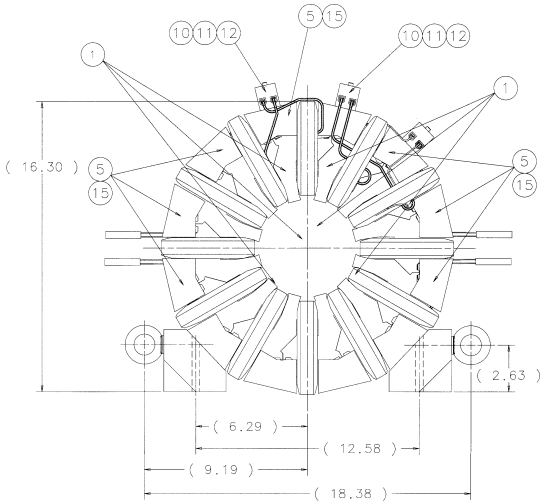
The scope of the load test was to verify the adequacy of the eye bolts in their as-intended orientation (i.e. with the load perpendicular to the shaft of the bolt). This test was conducted under the supervision of our lifting engineer on 25-Apr-2007. We used a G10 block with inserts identical to the ones on the magnet. Two bolts were installed in the same orientation as used on the magnets. In lifting a load of 425 pounds (212.5 pounds/bolt) the bolts held with no indication of a problem. The 500-pound magnet was designed to be lifted by four bolts (125 pounds/bolt). The lifting engineer approved this configuration on 03-May-2007. The bolts used for this test were received from the FNAL Stock Room,

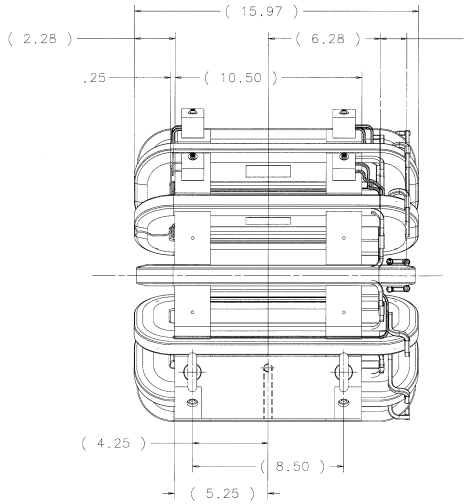
which did not have a Zinc plating. The change to the Zinc-plated bolts from did not warrant an additional test.

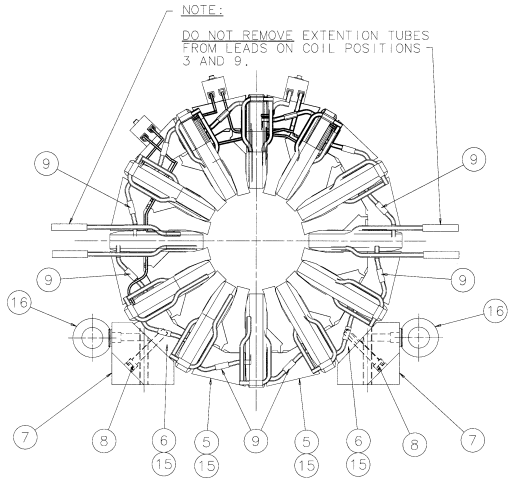
Despite the calculations and the load test, there were still lingering concerns over the use of the eye bolts in this configuration. As a result, on 08-May-07 it was decided to purchase and use swivel bolts (McMaster-Carr part number 29994T64). The swivel bolts were first issued to production on 15-May-07, with a recommendation to use them instead of the eye bolts. After the eye bolt broke the recommendation became a requirement.

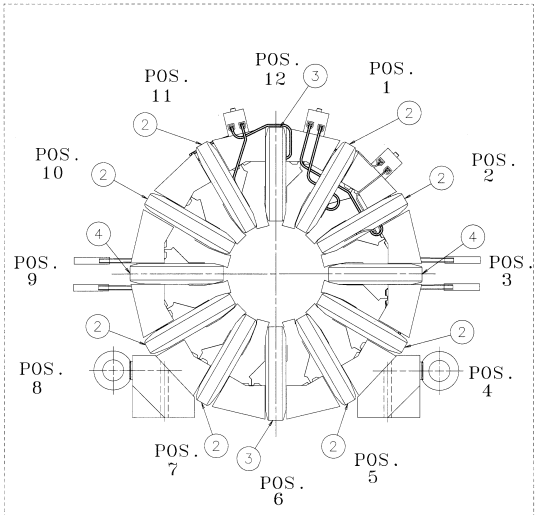
Title of Persons Involved with this Investigation
Jamie Blowers, QA Officer, TD Magnet Systems Department (MSD)
Sasha Makarov, Project Engineer, TD MSD
Earl Schaffer, MSD Technician
Tug Arkan, Lifting Engineer, TD Superconducting Radio Frequency Department (SRFD)
Marsha Schmidt, Acquisitioner, TD Material Control Department (MCD)
David Harding, Project Physicist, TD MSD
Ted Beale, QC Supervisor, TD MCD
Dennis Gaw, Inspector, TD MSD
Gregg Kobliska, TD MCD Head
Rich Ruthe, Senior Safety Officer, TD Support Department
Inpeng Samayavong, Lead Technician, TD MSD
Dan Smith, Production Manager, TD MSD
Romesh Sood, TD Associate Head
John Zweibohmer, Acquisition Group Leader, TD MCD

REV.	DESCRIPTION	DRAWN / APPD.	DATE
	ER#-8631		
A	SEE SHEET 2 FOR REV. DETAILS ECO-8672	JNJ / A.MAKAROV	3-26-07 / 3-27-07
B	DELETED ITEM 11 IN P/L-SHT 1 SHT 2 POS#8 TYPE 2 VENDOR DESIG. C2 WAS C3;NORM SEXT NOTE BLUE WAS BLACK ECO-8674	JNJ / A.MAKAROV	4-6-07 / 4-6-07
C	REV. P/L ITEM 16 MA-393841 WAS MA-393720;REV. LEADS ECO-8680	JNJ /	4-25-07 / 5/30/07

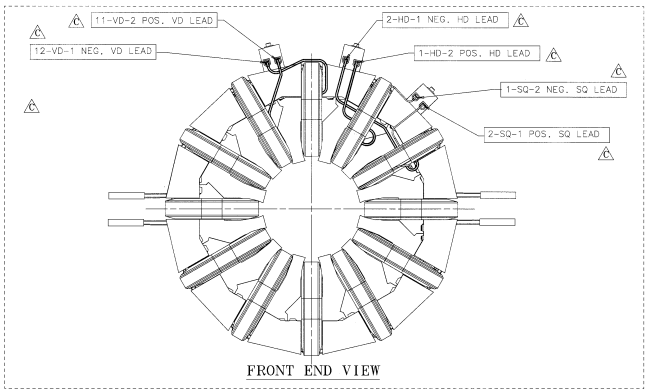




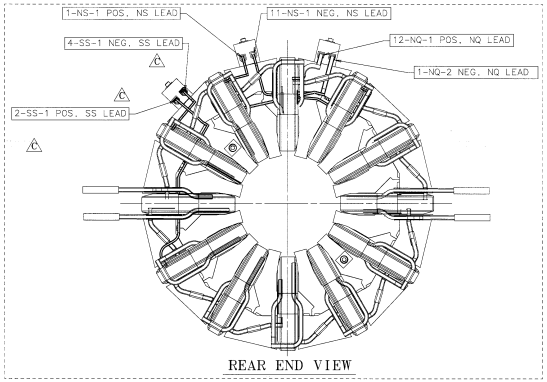




FRONT VIEW
COIL POSITIONS
SEE SHEET 2 FOR
COIL LEAD CONNECTIONS



FRONT END VIEW



REAR END VIEW

NOTES:

1. ASSEMBLE THE MAGNET PER DWG.#ME-445004, USING THE MAGNET ASSY. FIXTURE (ME-445336)AND THE FIXED MANDREL(MB-445369). CAREFULLY TRIM AND BEND THE COIL COOLING TUBES AS REQUIRED.
2. BRAZE THE COIL COOLING TUBE COUPLINGS WITH SILFOS-15. CHECK EACH COOLING LINES WITH 500 PSI WATER PRESSURE, NO LEAKS SHALL BE DETECTABLE. MEASURE THE WATER FLOW THROUGH EACH OF THE WATER LINES. THE FLOW SHALL NOT BE LESS THAN 0.3 GPM AT 60 PSI WATER PRESSURE,AND 0.42 GPM AT 100 PSI.
3. INSULATE THE COOLING LINES JOINTS AREAS WITH ONE(1) LAYER HALF-LAPPED .007" X 1"ADHESIVE BACKED FIBERGLASS TAPE(ITEM 18).
4. VERIFY THAT THE COILS ARE LOOSE IN THE FIXTURE ALUMINUM CHANNELS.
5. PUSH THE ALUMINUM CHANNELS AGAINST THE CORE SEGMENTS TO OBTAIN THE MAGNET APERTURE ROUNDNESS WITHIN .002". MEASURE THE POLE-TO-POLE DISTANCE ON EACH MAGNET END, TIGHTEN THE ALIGNMENT SCREWS IN THE LARGE APERTURE AREAS, AND LOOSEN THE SCREWS IN THE SMALL APERTURE AREAS TO OBTAIN THE REQUIRED APERTURE ROUNDNESS.
6. APPLY THE COIL LEADS LABELS PER THE TABLE ON DWG. ME-445004 SHT. 2. THE LABELS ARE COLOR CODED FOR DIFFERENT WINDING(ALSO SEE SHT. 2).
7. CONNECT THE COIL LEADS PER THE ELECTRICAL SCHEMES ON DWG. ME-445004 SHT.2. DO NOT TRIM THE COIL LEADS AT THIS TIME.
8. VERIFY THE COIL LEADS CONNECTION USING THE WIRING CHECKING SYSTEM.
9. TRIM THE COIL LEADS TO CONNECT THEM THE SHORTEST POSSIBLE WAY. ASSURE COIL LEADS PASS FROM COIL TO COIL THRU THE COIL CORNER AREAS,AND CONNECTIONS ARE MADE IN AREAS BETWEEN COILS. TRIM LEADS IN ONLY ONE LOCATION AT THE TIME TO REDUCE THE POSSIBILITY OF MIS-WIRING.
10. BRAZE THE COIL LEADS WITH SILFOS-15. CLEANUP WIRES IN THE CONNECTION AREAS AND INSULATE THEM WITH ONE(1) LAYER,HALF-LAPPED FIBERGLASS TAPE(ITEM 18).
11. ALIGN THE COILS LONGITUDINALLY USING THE COIL ALIGNMENT FIXTURE(MC-445370).
12. HIPOT EACH TYPE OF WINDING AGAINST THE CORE AND COOLING LINES (500V, THE CURRENT LEAKAGE SHALL BE LESS THAN 5uA).
13. REMOVE THE COIL ALIGNMENT FIXTURE FROM THE MAGNET. ENSURE THE COILS DID NOT SHIFT AFTER THIS.
14. DAM GAPS BETWEEN COILS AND CURE SEGMENTS ON EACH MAGNET END WITH "PIG PUTTY"(ITEM 17) OR EQUIVALENT.
15. POUR PLAIN ROOM CURE EPOXY IN THE GAPS BETWEEN THE COILS AND THE CORE SEGMENTS FROM THE MAGNET APERTURE. POUR EPOXY ONLY IN 120° AREA IN THE LOWER PART OF THE APERTURE EACH TIME. WHEN THE EPOXY IS COMPLETELY CURED,ROTATE THE MAGNET 120° AND FILL GAPS AS BEFORE. AGIAN,WHEN THE EPOXY IS CURED, ROTATE THE MAGNET 120° AND FILL THE REMAINING GAPS. NO EPOXY BUILD-UPS OVER THE POLE TIPS IS ALLOWED.
16. ROTATE THE MAGNET UNTIL COIL #6 IS FACING UP. REMOVE THE ALUMINUM CHANNELS AND UPPER HALF OF ROTATING RINGS FROM THE FIXTURE.
17. INSTALL THE COIL SPACERS(ITEM 6)AND (2)MOUNTING FOOT(ITEM 7), ENSURING THEIR PROPER LOCATION WITH THE FIXTURE(MC-445373). GLUE SPACERS TO THE COILS WITH ROOM CURE FILLED EPOXY. KEEP THE CORE SURFACES CLEAN FROM EPOXY.
18. ONCE THE EPOXY IS COMPLETELY CURED,REMOVE THE MAGNET ASSY FROM THE FIXTURE. ROLL THE MAGNET ASSY. OVER AND PLACE ON MOUNTING FEET,PROTECT THE COIL LEADS AND MAGNET COOLING TUBES FROM DAMAGE DURING THE ROLL OVER AND INSTALLATION OPERATIONS.
19. INSTALL THE REMAINING G-10 COIL SPACERS(ITEM 5), ENSURING THEIR PROPER LOCATION WITH THE COIL SPACER LOCATION FIXTURE. GLUE SPACERS TO THE COILS WITH ROOM CURE FILLED EPOXY. KEEP THE CORE SURFACES CLEAN FROM EPOXY.
20. INSTALL THE TERMINAL BLOCKS ON THE G-10 COIL SPACERS. TRIM THE LEADS AND CONNECT THEM TO THE TERMINAL BLOCKS,PER DWG. ME-445004.
21. HIPOT EACH TYPE OF WINDINGS AGAINST THE CORE AND COOLING LINES (500V, THE CURRENT LEAKAGE SHALL BE LESS THAN 5uA). MEASURE AND RECORD R,Ls/100 Hz, AND Q/100 Hz FOR EACH WINDING.
22. MEASURE AND RECORD WATER FLOW AT 60 PSI WATER PRESSURE DROP IN EACH OF THE MAGNET COOLING LINES.

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
16	MA-393841	EYEBOLT W/SHOULDER	4
15	ES-331721	FILLED EPOXY MIX	A/R
14	MA-116256	SILFOS-15 ROD	A/R
13	MA-274695	ROOM CURE EPOXY	A/R
12	MA-393817	SOCKET HEAD CAP SCREW #8-32UNC X 2.00" LONG STAINLESS STEEL	6
11	--	---	--
10	MA-393625	TERMINAL BLOCK	6
9	MA-445326	COUPLING-COOLING TUBE	12
8	MA-393545	SOCKET HEAD CAP SCREW 3/8-16UNC X 2.50" LONG STAINLESS STEEL	4
7	MC-445308	MOUNTING FOOT	2
6	MB-445367	COIL SPACER BLOCK W/ 3/8-16 TAP	4
5	MB-445270	COIL SPACER BLOCK	20
4	ME-445214	COIL #3 ASSEMBLY	2
3	ME-445212	COIL #2 ASSEMBLY	2
2	ME-445210	COIL #1 ASSEMBLY	8
1	MC-445013	CORE SEGMENT ASSEMBLY	12
18	MA-274991	FIBERGLASS ADHESIVE TAPE	A/R
17	MA-393829	EPOXY REPAIR PUTTY	A/R

UNLESS OTHERWISE SPECIFIED: .XX ±.02, .XXX ±.010, ANGLES ±.5°
1. BREAK ALL SHARP EDGES .02 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ANSI Y14.5M-1982
4. MAX. ALL MACH. SURFACES 125√

ORIGINATOR: DRAWN JABLONSKI 12-08-06; CHECKED A.MAKAROV 2-21-07; APPROVED A.MAKAROV 2-21-07
USED ON
MATERIAL: SEE LIST

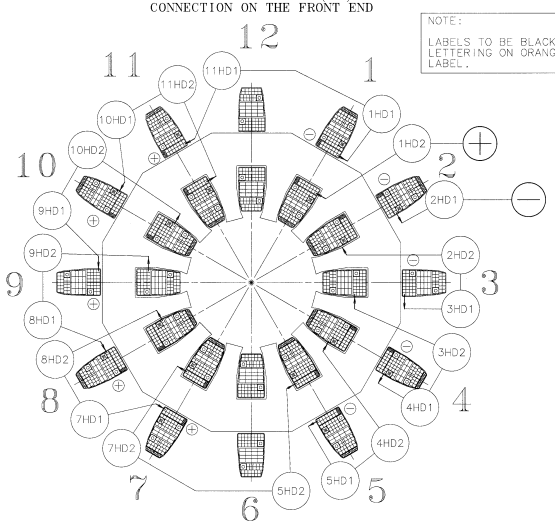
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

BOOSTER CORRECTION PACKAGE CORE AND COIL ASSEMBLY

SCALE 3:8 | FILMED | DRAWING NUMBER 5520-ME-445004 SHT 1 OF 2 | REV. C
CREATED WITH I-DEAS MS-5 | USER NAME: jablon

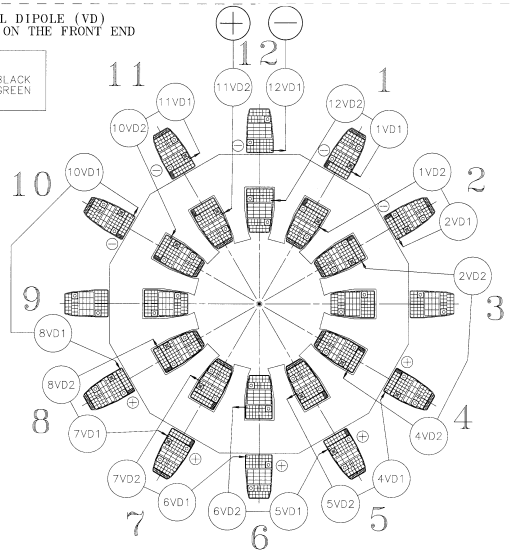
HORIZONTAL DIPOLE (HD)
CONNECTION ON THE FRONT END

NOTE:
LABELS TO BE BLACK LETTERING ON ORANGE LABEL.



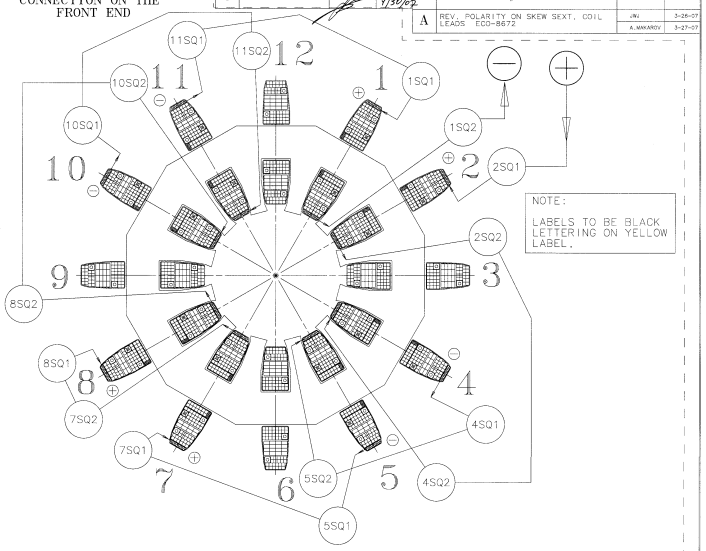
VERTICAL DIPOLE (VD)
CONNECTION ON THE FRONT END

NOTE:
LABELS TO BE BLACK LETTERING ON GREEN LABEL.



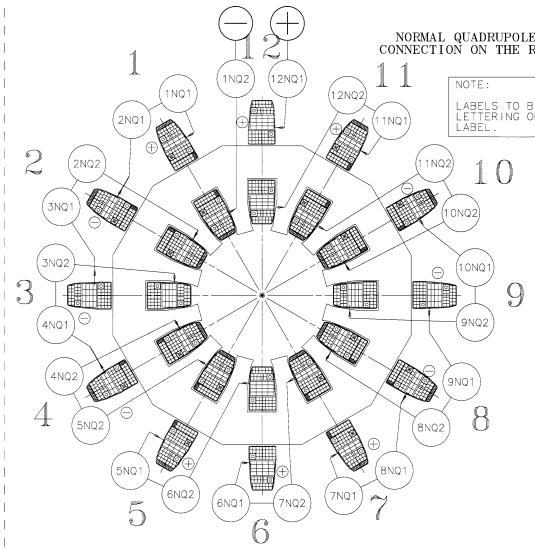
SKEW QUADRUPOLE (SQ)
CONNECTION ON THE FRONT END

NOTE:
LABELS TO BE BLACK LETTERING ON YELLOW LABEL.



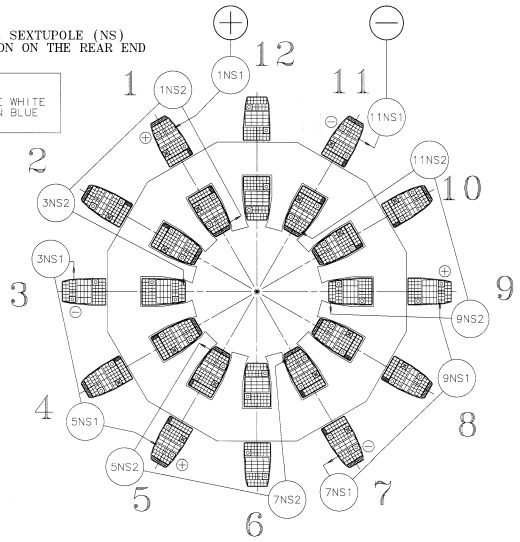
NORMAL QUADRUPOLE (NQ)
CONNECTION ON THE REAR END

NOTE:
LABELS TO BE BLACK LETTERING ON RED LABEL.



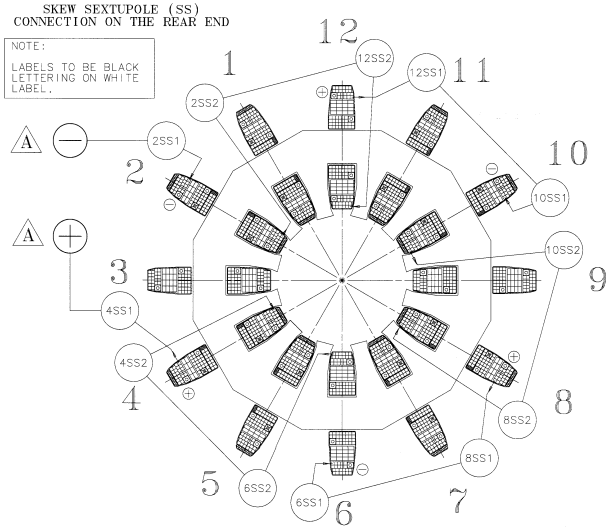
NORMAL SEXTUPOLE (NS)
CONNECTION ON THE REAR END

B NOTE:
LABELS TO BE WHITE LETTERING ON BLUE LABEL.



SKEW SEXTUPOLE (SS)
CONNECTION ON THE REAR END

NOTE:
LABELS TO BE BLACK LETTERING ON WHITE LABEL.



REV.	DESCRIPTION	DRAWN	DATE
		APPD.	DATE
B	SEE SHEET 1 FOR REV. DESCRIPTIONS ECO-8674	JWJ	4-5-07
		A. MAKAROV	4-6-07
C	SEE SHEET 1 FOR REV. DESCRIPTIONS ECO-8680	JWJ	4-25-07
			4/30/07
	ER-#8631		
A	REV. POLARITY ON SKEW SEXT. COIL LEADS ECO-8672	JWJ	3-26-07
		A. MAKAROV	3-27-07

COIL POSITION IN CORE	COIL TYPE	VENDOR LEAD DESIGNATION	FERMI LEAD DESIGNATION	JOINT LOCATION	NOTES
POSITION #1	TYPE #1	C1-S1-1	1-HD-1	FRONT END	
		C1-S1-2	1-HD-2		POS.HD LEAD
		C1-S2-1	1-VD-1	FRONT END	
		C1-S2-2	1-VD-2		
		C1-S3-1	1-NQ-1	BACK END	
		C1-S3-2	1-NQ-2		NEG.NQ LEAD
		C1-S4-1	1-NS-1	BACK END	POS.NS LEAD
		C1-S4-2	1-NS-2		
		C1-S5-1	1-SQ-1	FRONT END	
		C1-S5-2	1-SQ-2		NEG.SQ LEAD
POSITION #2	TYPE #1	C1-S1-1	2-VD-1	FRONT END	
		C1-S1-2	2-VD-2		
		C1-S2-1	2-HD-1	FRONT END	
		C1-S2-2	2-HD-2		NEG.HD LEAD
		C1-S3-1	2-NQ-1	BACK END	
		C1-S3-2	2-NQ-2		
		C1-S4-1	2-SS-1	BACK END	POS.SS LEAD
		C1-S4-2	2-SS-2		
		C1-S5-1	2-SQ-1	FRONT END	POS.SQ LEAD
		C1-S5-2	2-SQ-2		
POSITION #3	TYPE #3	C3-S1-1	3-HD-1	FRONT END	
		C3-S1-2	3-HD-2		
		C3-S2-1	3-NQ-1	BACK END	
		C3-S2-2	3-NQ-2		
		C3-S3-1	3-NS-1	BACK END	
		C3-S3-2	3-NS-2		
POSITION #4	TYPE #1	C1-S1-1	4-VD-1	FRONT END	
		C1-S1-2	4-VD-2		
		C1-S2-1	4-HD-1	FRONT END	
		C1-S2-2	4-HD-2		
		C1-S3-1	4-NQ-1	BACK END	
		C1-S3-2	4-NQ-2		
		C1-S4-1	4-SS-1	BACK END	NEG.SS LEAD
		C1-S4-2	4-SS-2		
		C1-S5-1	4-SQ-1	FRONT END	
		C1-S5-2	4-SQ-2		
POSITION #5	TYPE #1	C1-S1-1	5-HD-1	FRONT END	
		C1-S1-2	5-HD-2		
		C1-S2-1	5-VD-1	FRONT END	
		C1-S2-2	5-VD-2		
		C1-S3-1	5-NQ-1	BACK END	
		C1-S3-2	5-NQ-2		
		C1-S4-1	5-NS-1	BACK END	
		C1-S4-2	5-NS-2		
		C1-S5-1	5-SQ-1	FRONT END	
		C1-S5-2	5-SQ-2		
POSITION #6	TYPE #2	C2-S1-1	6-VD-1	FRONT END	
		C2-S1-2	6-VD-2		
		C2-S2-1	6-NQ-1	BACK END	
		C2-S2-2	6-NQ-2		
		C2-S3-1	6-SS-1	BACK END	
		C2-S3-2	6-SS-2		
POSITION #7	TYPE #1	C1-S1-1	7-HD-1	FRONT END	
		C1-S1-2	7-HD-2		
		C1-S2-1	7-VD-1	FRONT END	
		C1-S2-2	7-VD-2		
		C1-S3-1	7-NQ-1	BACK END	
		C1-S3-2	7-NQ-2		
		C1-S4-1	7-NS-1	BACK END	
		C1-S4-2	7-NS-2		
		C1-S5-1	7-SQ-1	FRONT END	
		C1-S5-2	7-SQ-2		
POSITION #8	TYPE #1	C1-S1-1	8-VD-1	FRONT END	
		C1-S1-2	8-VD-2		
		C1-S2-1	8-HD-1	FRONT END	
		C1-S2-2	8-HD-2		
		C1-S3-1	8-NQ-1	BACK END	
		C1-S3-2	8-NQ-2		
		C1-S4-1	8-SS-1	BACK END	
		C1-S4-2	8-SS-2		
		C1-S5-1	8-SQ-1	FRONT END	
		C1-S5-2	8-SQ-2		
POSITION #9	TYPE #3	C3-S1-1	9-HD-1	FRONT END	
		C3-S1-2	9-HD-2		
		C3-S2-1	9-NQ-1	BACK END	
		C3-S2-2	9-NQ-2		
		C3-S3-1	9-NS-1	BACK END	
		C3-S3-2	9-NS-2		
POSITION #10	TYPE #1	C1-S1-1	10-VD-1	FRONT END	
		C1-S1-2	10-VD-2		
		C1-S2-1	10-HD-1	FRONT END	
		C1-S2-2	10-HD-2		
		C1-S3-1	10-NQ-1	BACK END	
		C1-S3-2	10-NQ-2		
		C1-S4-1	10-SS-1	BACK END	
		C1-S4-2	10-SS-2		
		C1-S5-1	10-SQ-1	FRONT END	
		C1-S5-2	10-SQ-2		
POSITION #11	TYPE #1	C1-S1-1	11-HD-1	FRONT END	
		C1-S1-2	11-HD-2		
		C1-S2-1	11-VD-1	FRONT END	
		C1-S2-2	11-VD-2		POS.VD LEAD
		C1-S3-1	11-NQ-1	BACK END	
		C1-S3-2	11-NQ-2		
		C1-S4-1	11-NS-1	BACK END	NEG.NS LEAD
		C1-S4-2	11-NS-2		
		C1-S5-1	11-SQ-1	FRONT END	
		C1-S5-2	11-SQ-2		
POSITION #12	TYPE #2	C2-S1-1	12-VD-1	FRONT END	NEG.VD LEAD
		C2-S1-2	12-VD-2		
		C2-S2-1	12-NQ-1	BACK END	POS.NQ LEAD
		C2-S2-2	12-NQ-2		
		C2-S3-1	12-SS-1	BACK END	
		C2-S3-2	12-SS-2		

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
		PARTS LIST	

UNLESS OTHERWISE SPECIFIED: .XX ±, .XXX ±, ANGLES ±
1. BREAK ALL SHARP EDGES .02 MAX
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ANSI-Y14.5M-1982
4. MAX. ALL MACH. SURFACES

ORIGINATOR
DRAWN: MAKAROV/JABLONSKI 1-10-07
CHECKED: A.MAKAROV 2-21-07
APPROVED: A.MAKAROV 2-21-07
USED ON
MATERIAL

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

BOOSTER CORRECTION PACKAGE CORE AND COIL ASSEMBLY COIL LEADS CONNECTION SCHEME

SCALE: 1:2 | FILMED | DRAWING NUMBER: 5520-ME-445004 | SHT 2 OF 2 | REV: C

CREATED WITH I-DEAS MS1.3b | USER NAME: robin

ECO

TD Engineering Change Order

 Thu May 31 22:51:11 CDT 2007

ECO # 8680

Created Date 2007-04-25 15:16:04.267 **Modified Date** 2007-05-01 14:57:01.42

Initiator J. Jablonski **Approval** A. Makarov

Project Title 105 Booster Multipole Corrector

Project1 32 **Task1** 1.02.03.20 **Project2** **Task2** **Budget Code**

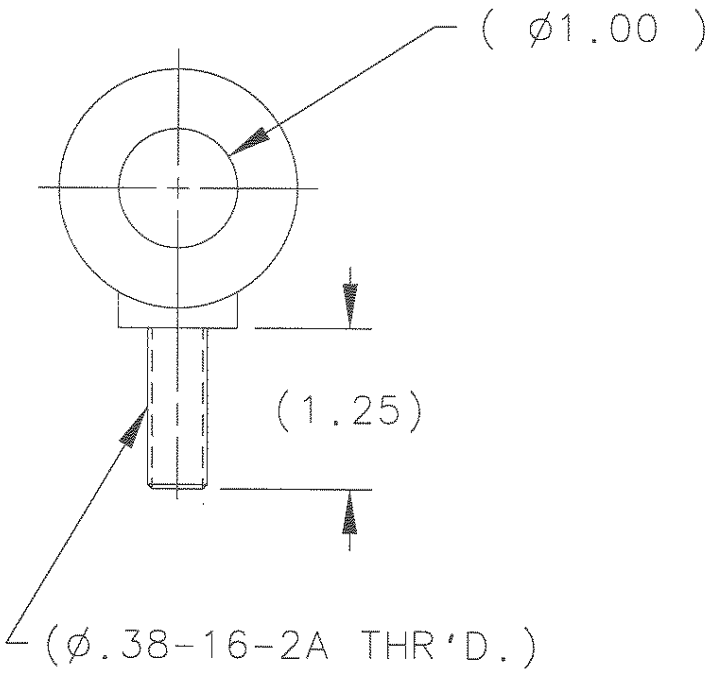
Phone # **Location** **Required Date**

Notes

Action Code: 1) Add to Inventory 2) Order for Project 3) Cancel Outstanding Orders 4) Rework Stock 5) Issue Changes to Orders 6) Scrap Stock 7) See Special Notes

Size	Part#	Rev	Act Code	Description
ME	445004	C	7	Booster Correction Package | Core And Coil Assembly (2 sheets)
MC	445308	B	4	Booster Correction Package | Mounting Foot
MB	445356	A	4	Booster Correction Package | Magnet Assembly | Manifold Support Assembly

REV.	DESCRIPTION	DRAWN	DATE
	E.R. #6713	APPD.	DATE



EYEBOLT WITH SHOULDER
SIZE: 3/8"-16
WORKING LOAD LIMIT: 1300 #
MAT'L.: PLAIN STEEL, ZINC PLATED

PART # 3014T253 OR ENGINEERING EQUIVALENT

McMASTER-CARR SUPPLY CO.
P.O. BOX 4355
CHICAGO, IL. 60680-4355
PH, # (630)-833-0300

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
		PARTS LIST	

UNLESS OTHERWISE SPECIFIED			ORIGINATOR		
.XX	.XXX	ANGLES	DRAWN	JABLONSKI	4-24-07
±	±	±	CHECKED		
1. BREAK ALL SHARP EDGES .02 MAX.			APPROVED		4/24/07
2. DO NOT SCALE DRAWING.			USED ON		
3. DIMENSIONS BASED UPON ASME Y14.5M-1994					
4. MAX. ALL MACH. SURFACES √			MATERIAL	NOTED	

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

COMMON FASTENERS
EYEBOLT WITH SHOULDER
ø3/8-16 x 1.25" LG. PLAIN STEEL

SCALE	FILMED	DRAWING NUMBER	REV.
NTS		5520-MA-393841	

CREATED WITH I-DEAS 9m3 | USER NAME: jablon

MACHINERY EYE BOLTS

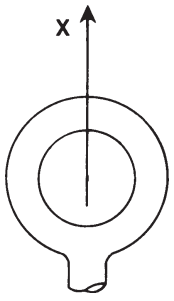
Maximum blank lengths, either pattern indicated in column (1). Vertical loads are based on a safety factor of 5 to 1. Variation in quantity: on special items we reserve the right to a maximum 10% variation for allowances in manufacture.

Standard Shank Lengths – Plain & Shoulder Pattern

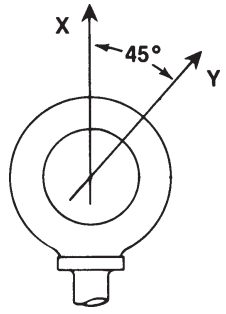
Stock Numbers		Dimensions – Inches						
Plain Pattern	Shoulder Pattern	Shank		Eye		Overall Length Plain	Overall Length Shoulder	Maximum Lengths (1)
		Dia. & Thread	Length	I.D.	O.D.			
1	21	1/4"-20	1"	3/4"	1-1/4"	2-1/4"	2-3/8"	3"
2	22	5/16"-18	1-1/8"	7/8"	1-1/2"	2-5/8"	2-3/4"	4"
3	23	3/8"-16	1-1/4"	1"	1-21/32"	2-29/32"	3-1/4"	4-1/2"
4	24	7/16"-14	1-3/8"	1-3/32"	1-27/32"	3-7/32"	3-5/8"	4-1/2"
5	25	1/2"-13	1-1/2"	1-3/16"	2-1/16"	3-9/16"	4"	4-1/2"
6	26	9/16"-12	1-5/8"	1-9/32"	2-9/32"	3-29/32"	4-1/2"	4-1/2"
7	27	5/8"-11	1-3/4"	1-3/8"	2-1/2"	4-1/4"	4-7/8"	4-1/2"
8	28	3/4"-10	2"	1-1/2"	2-13/16"	4-13/16"	5-1/4"	5"
9	29	7/8"-9	2-1/4"	1-11/16"	3-1/4"	5-1/2"	6"	5"
10	30	1"-8	2-1/2"	1-13/16"	3-9/16"	6-1/16"	7"	5"
11	31	1-1/8"-7	2-3/4"	2"	4"	6-3/4"	7-1/2"	2-3/4"
12	32	1-1/4"-7	3"	2-3/16"	4-7/16"	7-7/16"	8-1/2"	3"
14	34	1-1/2"-6	3-1/2"	2-1/2"	5-3/16"	8-11/16"	9-1/2"	3-1/2"

Working load limits for eye bolts are based on a straight vertical lift in a gradually increasing manner. Angular lifts will significantly lower working load limits (see Shoulder Pattern) and should be avoided whenever possible. If an angular lift is required, a properly seated Shoulder Pattern eye bolt must be used. Loads should always be applied to eye bolts in the plane of the eye, not at an angle to this plane. Angular lifts must never be more than a 45° pull. **For angular lifting see page 23.**

Diameter and Thread	Working Load Limit	
	Straight Pull (X)	45° Pull (Y) Shoulder Only
1/4"-20	500	125
5/16"-18	900	225
3/8"-16	1400	350
7/16"-14	2000	500
1/2"-13	2600	650
9/16"-12	3200	750
5/8"-11	4000	1000
3/4"-10	6000	1500
7/8"-9	7000	1750
1"-8	9000	2250
1-1/8"-7	12000	2500
1-1/4"-7	15000	3750
1-1/2"-6	21000	4900



Plain Pattern



Shoulder Pattern

ANGULAR LIFTS SHOULD BE AVOIDED WHENEVER POSSIBLE.

MACHINERY EYE BOLTS

Drop forged steel. Heat treated after forging. Self-colored, zinc plated, or hot galvanized. Plain or shoulder type, blank or threaded. Threaded will be supplied unless otherwise specified. See additional specifications and dimensions on page 18.

Available in Zinc Plated and Hot Galvanized. See page 20.

Some sizes available in Stainless Steel. See page 48.

Available in Metric See page 22.

Standard Shank Lengths
Plain Pattern

Plain Pattern No.	Bolt Diameter N.C.	Standard Shank Length	Threaded		Blank	
			Part No.	Weight Per 100	Part No.	Weight Per 100
1	1/4"	1"	11605 3	5	11005 1	5.5
2	5/16"	1-1/8"	11625 1	10.5	11025 9	11.5
3	3/8"	1-1/4"	11645 9	15.5	11045 7	16.5
4	7/16"	1-3/8"	11665 7	20.5	11065 5	22
5	1/2"	1-1/2"	11685 5	33	11085 3	35
6	9/16"	1-5/8"	11705 0	44.5	11105 8	45
7	5/8"	1-3/4"	11725 8	64	11125 6	66
8	3/4"	2"	11748 7	90.5	11148 5	97
9	7/8"	2-1/4"	11768 5	135	11168 3	142
10	1"	2-1/2"	11788 3	190.5	11188 1	199
11	1-1/8"	2-3/4"	11808 8	299.5	11208 6	312
12	1-1/4"	3"	11831 6	399	11231 4	412
14	1-1/2"	3-1/2"	11851 4	662.5	11251 2	691

Standard Shank Lengths
Shoulder Pattern

Shoulder Pattern No.	Bolt Diameter N.C.	Standard Shank Length	Threaded		Blank	
			Part No.	Weight Per 100	Part No.	Weight Per 100
21	1/4"	1"	12805 6	6	12205 4	6
22	5/16"	1-1/8"	12825 4	10	12225 2	10.5
23	3/8"	1-1/4"	12845 2	16	12245 0	17
24	7/16"	1-3/8"	12865 0	26.5	12265 8	28
25	1/2"	1-1/2"	12885 8	38	12285 6	39
26	9/16"	1-5/8"	12905 3	49	12305 1	52.5
27	5/8"	1-3/4"	12925 1	73.5	12325 9	76.5
28	3/4"	2"	12948 0	99.5	12348 8	104
29	7/8"	2-1/4"	12968 8	172.5	12368 6	178
30	1"	2-1/2"	12988 6	235	12388 4	242
31	1-1/8"	2-3/4"	13008 0	342.5	12408 9	347
32	1-1/4"	3"	13031 8	462.5	12431 7	485
34	1-1/2"	3-1/2"	13051 6	752.5	12451 5	780

PLATED MACHINERY EYE BOLTS

ZINC PLATED

PLAIN PATTERN – ZINC

Plain Pattern No.	Bolt Diameter N.C.	Standard Shank Length	Part No.
1	1/4"	1"	26005 3
2	5/16"	1-1/8"	26008 4
3	3/8"	1-1/4"	26011 4
4	7/16"	1-3/8"	26014 5
5	1/2"	1-1/2"	26017 6
6	9/16"	1-5/8"	26020 6
7	5/8"	1-3/4"	26023 7
8	3/4"	2"	26026 8
9	7/8"	2-1/4"	26029 9
10	1"	2-1/2"	26032 9
11	1-1/8"	2-3/4"	26035 0
12	1-1/4"	3"	26038 1
14	1-1/2"	3-1/2"	26041 1

SHOULDER PATTERN – ZINC

Shoulder Pattern No.	Bolt Diameter N.C.	Standard Shank Length	Part No.
21	1/4"	1"	26050 3
22	5/16"	1-1/8"	26053 4
23	3/8"	1-1/4"	26056 5
24	7/16"	1-3/8"	26059 6
25	1/2"	1-1/2"	26062 6
26	9/16"	1-5/8"	26065 7
27	5/8"	1-3/4"	26068 8
28	3/4"	2"	26071 8
29	7/8"	2-1/4"	26074 9
30	1"	2-1/2"	26077 0
31	1-1/8"	2-3/4"	26080 0
32	1-1/4"	3"	26083 1
34	1-1/2"	3-1/2"	26086 2

HOT GALVANIZED

PLAIN PATTERN – GALVANIZED

Plain Pattern No.	Bolt Diameter N.C.	Standard Shank Length	Part No.
1	1/4"	1"	26105 0
2	5/16"	1-1/8"	26108 1
3	3/8"	1-1/4"	26111 1
4	7/16"	1-3/8"	26114 2
5	1/2"	1-1/2"	26117 3
6	9/16"	1-5/8"	26120 3
7	5/8"	1-3/4"	26123 4
8	3/4"	2"	26126 5
9	7/8"	2-1/4"	26129 6
10	1"	2-1/2"	26132 6
11	1-1/8"	2-3/4"	26135 7
12	1-1/4"	3"	26138 8
14	1-1/2"	3-1/2"	26141 8

SHOULDER PATTERN – GALVANIZED

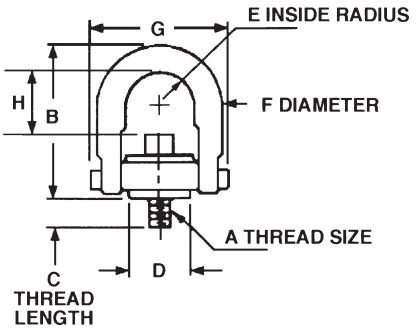
Shoulder Pattern No.	Bolt Diameter N.C.	Standard Shank Length	Part No.
21	1/4"	1"	26155 5
22	5/16"	1-1/8"	26158 6
23	3/8"	1-1/4"	26161 6
24	7/16"	1-3/8"	26164 7
25	1/2"	1-1/2"	26167 8
26	9/16"	1-5/8"	26170 8
27	5/8"	1-3/4"	26173 9
28	3/4"	2"	26176 0
29	7/8"	2-1/4"	26179 1
30	1"	2-1/2"	26182 1
31	1-1/8"	2-3/4"	26185 2
32	1-1/4"	3"	26188 3
34	1-1/2"	3-1/2"	26191 3

ALLOY STEEL SWIVEL HOIST RINGS

NEW!

Chicago Hardware is proud to announce the addition of Center Pull Style Swivel Hoist Rings to its product line. This is the ideal product for angular lift applications. These Swivel Hoist Rings have full swivel and pivot action.

Our hoist rings are alloy steel with a black oxide finish. They adhere to the same rigid quality standards that have been a part of Chicago Hardware's proud tradition since 1912. Individually proof tested and magnetic particle inspected. From 800 to 24,000 lb load capacities (Rated at 5:1 safety factor).



Part No.	Thread Size (A)	Working Load Limit	Thread Length (C)	B	D	E	F	G	H	Torque
86004 8	5/16"-18	800	9/16"	2.67"	0.75"	0.43"	0.38"	1.84"	1-1/4"	7
86007 9	3/8"-16	1000	9/16"	2.67"	0.75"	0.43"	0.38"	1.84"	1-1/4"	12
86013 0	1/2"-13	2500	3/4"	4.78"	1.5"	0.88"	0.75"	3.52"	2-3/8"	28
86016 1	1/2"-13	2500	1"	4.78"	1.5"	0.88"	0.75"	3.52"	2-3/8"	28
86019 2	1/2"-13	2500	1-1/4"	4.78"	1.5"	0.88"	0.75"	3.52"	2-3/8"	28
86022 2	5/8"-11	4000	1"	4.78"	1.5"	0.88"	0.75"	3.52"	2-1/4"	60
86025 3	5/8"-11	4000	1-1/4"	4.78"	1.5"	0.88"	0.75"	3.52"	2-1/4"	60
86028 4	3/4"-10	5000	1"	4.78"	1.5"	0.88"	0.75"	3.52"	2-1/8"	100
86031 4	3/4"-10	5000	1-1/2"	4.78"	1.5"	0.88"	0.75"	3.52"	2-1/8"	100
86034 5	3/4"-10	7000	1"	6.52"	2.31"	1.4"	1"	5.14"	2-15/16"	100
86037 6	3/4"-10	7000	1-1/2"	6.52"	2.31"	1.4"	1"	5.14"	2-15/16"	100
86043 7	7/8"-9	8000	1-1/4"	6.52"	2.31"	1.4"	1"	5.14"	2-13/16"	160
86046 8	1"-8	10000	1-1/4"	6.52"	2.31"	1.4"	1"	5.14"	2-11/16"	230
86049 9	1"-8	10000	1-1/2"	6.52"	2.31"	1.4"	1"	5.14"	2-11/16"	230
86052 9	1"-8	10000	2-1/4"	6.52"	2.31"	1.4"	1"	5.14"	2-11/16"	230
86055 0	1-1/4"-7	15000	1-7/8"	8.73"	3.19"	1.75"	1.25"	6.5"	4-1/4"	470
86061 1	1-1/2"-6	24000	2-3/4"	12.47"	4.19"	2.25"	1.75"	8.55"	6-1/2"	800

WARNING: DO NOT EXCEED SAFE WORK LOAD

Made in USA

FAX - Fermilab Procard Order

From: FERMILAB
Contact: SCHMIDT, MARSHA E
Phone: 630/840 4377
-

Attention:
Company: MCMASTER -CARR
Phone: 630-833-0300

Fax:

Order Number: **PRN91400** *** THIS IS NOT AN ORDER UNTIL CONFIRMED ***

Note: BMA Magnets 32/1.02.03.20
Route, inspect, stock (MA 393841)

Ship To: FERMILAB - SCHMIDT, MARSHA E
ORDER# PRN91400
WILSON & KIRK ROADS
BATAVIA IL 60510-0500

Approval:_____

Line	Item Description	Qty	Unit	Price	Total
1	Forged Zinc-Plated Steel Lifting Eyebolt with Shoulder, 3/8-16 x 1.25", #3014T253	150.00	EACH	5.39	$808.50
2	Shipping	1.00	EACH	7.50	$7.50
			Order Total:		**$816.00**

New Entry | Duo Entry | Entry For m | Log | Find | Print | Parts Log | Parts Accepted

Routing Form Number 86210

Part Number MA 393841 | Revision NONE | Date Apr 26, 2007

P.O. Number PRN91400 | QC Task # 32/1.02.03.20

Task Shop # N/A | Amount of part received 150

Description EYEBOLT W/SHOULDER, 3/8-16 x 1.25"

Vendor McMASTERR-CARR

Requisitioner MS | Intials TB

Inspect? Yes | **Cert** No | **Rework?** No | **Ref: QCR#**

Number of Packages 1 | Type of Container BOX | Location Insp. Shelf

Disposition ROUTE, INSPECT, STOCK

Notes

Sign Off Person

PARTS ACCEPTED

Amount 150 | Date 4/26/2007

Placed in stock by CB12698 | Location R7,S2,L2

Notes

Sign Off ID#

TD Inventory Transaction History List

Tue May 22 14:46:09 CDT 2007

Part	Rev	Location	Date	Dscr	Bal	Qty	Sir	Activity	SRID	PRID	Bud1	Bud2	Proj1	Task1	Proj2	Task2	Rem	Rout	PO	MMR
393841		R7,2,2	2007-05-17	EYEBOLT W/SHOULDER, 3/8-16 x 1.25"	122	4		Issue	besch	gardner			A0601	1.02.03.02			Issue:(-) 4. KIT-BMA	009		
393841		R7,2,2	2007-05-17	EYEBOLT W/SHOULDER, 3/8-16 x 1.25"	126	4		Issue	besch	gardner			A0601	1.02.03.02			Issue:(-) 4. KIT-BMA	008		
393841		R7,2,2	2007-05-17	EYEBOLT W/SHOULDER, 3/8-16 x 1.25"	130	4		Issue	besch	gardner			A0601	1.02.03.02			Issue:(-) 4. KIT-BMA	007		
393841		R7,2,2	2007-05-17	EYEBOLT W/SHOULDER, 3/8-16 x 1.25"	134	4		Issue	besch	gardner			A0601	1.02.03.02			Issue:(-) 4. KIT-BMA	006		
393841		R7,2,2	2007-05-17	EYEBOLT W/SHOULDER, 3/8-16 x 1.25"	138	4		Issue	besch	gardner			A0601	1.02.03.02			Issue:(-) 4. KIT-BMA	012		
393841		R7,2,2	2007-05-03	EYEBOLT W/SHOULDER, 3/8-16 x 1.25"	142	4		Issue	besch	bobjensen			A0601	1.02.03.02			Issue:(-) 4. KIT-BMA	005		
393841		R7,2,2	2007-05-03	EYEBOLT W/SHOULDER, 3/8-16 x 1.25"	146	4		Issue	besch	bobjensen			A0601	1.02.03.02			Issue:(-) 4. KIT-BMA	002		
393841		IB4	2007-04-26		0	150		Loc Trans	besch				32	1.02.03.20			to :R7,2,2. Receipt:(+) 150.	PRN91	400	
393841		R7,2,2	2007-04-26	EYEBOLT W/SHOULDER, 3/8-16 x 1.25"	150	150		Loc Trans	besch				32	1.02.03.20			from :IB4. Receipt:(+) 150.	PRN91	400	
393841		IB4	2007-04-26		150	150		Receipt	besch				32	1.02.03.20			Receipt:(+) 150.	PRN91	400	

TD - Engineering Fabrication Component Kit List

Process Engineering

Component Serial No.	BMA002-0	
Kit submitted by:	Bob Jensen	3173
Fermi ID No.	315	
Date submitted:	24-Apr-07	
Need date:	30-Apr-07	
Deliver to:	IB2	
Use with Traveler No.	333844	
Job No.	408	
M&S task number:	A0601/1.02.03.02	
Drawing Title:	Booster Corrector Magnet Assembly	
Drawing No.	ME-445311	Rev None

Material Control

Parts available

Verified by:	M. Schmidt MS
Fermi ID No.	04223N
Date submitted to stockroom:	4/26/2007

Parts issued

Issued by:	[signature]
Fermi ID No.	12698
Date issued:	5/1/07
Parts received by E&F:	Bob Jensen
Fermi ID No.	0315
Date received by E&F:	5/1/07

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256		ea	A/R	IB# 2 has				
2	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has				
3	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has				
4	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	22A2	4	✓	86146	152 pcs.
5	Terminal Block	MA	393625		ea	6	26C1	6	✓	85939	SWCM-001900 379 pcs.
6	Eyebolt w/shoulder	MA	393841		ea	4	IB4	4	✓	86210	150 pcs. - In QC
7	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	19B7	6	✓	86129	400 pcs.
8	Core Segment Assembly	MC	445013		ea	12	IB#2 has				SWCM-000800
9	Coil Assembly #1	ME	445210		ea	8	IB#2 has				SWCM-000400
10	Coil Assembly #2	ME	445212		ea	2	IB#2 has				SWCM-000500

TD - Engineering Fabrication Component Kit List

TD-07-010 Appendix I

Process Engineering

Component Serial No.	BMA003-0	
Kit submitted by:	Bob Jensen	3173
Fermi ID No.	315	
Date submitted:	03-Apr-07	
Need date:	6-Apr-07	
Deliver to:	IB2	
Use with Traveler No.	333844	
Job No.	408	
M&S task number:	A0601/1.02.03.02	
Drawing Title:	Booster Corrector Magnet Assembly	
Drawing No.	ME-445311	Rev None

Material Control

Parts available

Verified by:	Jack Zwalen
Fermi ID No.	6080
Date submitted to stockroom:	4/5/07

Parts issued

Issued by:	Eric Barnes
Fermi ID No.	14219
Date issued:	4/20/07
Parts received by E&F:	4/20/07 Bob Jensen 0315
Fermi ID No.	11003
Date received by E&F:	4/27/07

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	A/R	1C3				SP76-052200
2	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has				Mixed in IB#2
3	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has				Mixed in IB#2
4	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	IB#2 has	4	Sasha Reid	—	Attached to Kit List
5	Terminal Block	MA	393625		ea	6	26C1	6	Sasha Reid	85706	SIR # Pending
6	Eyebolt w/shoulder	MA	~~393720~~ 395841	A	ea	4	~~IB#4~~ 16A8	4	✓	86099	SIR # Pending
7	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	~~Due 4/5~~ 19B7	6	✓	86129	
8	Core Segment Assembly	MC	445013	C	ea	12	IB#2 has			85844/85888	SWCM-000800
9	Coil Assembly #1	ME	445210	E	ea	8	IB#2 has			86008	SWCM-000400
10	Coil Assembly #2	ME	445212	D	ea	2	IB#2 has			86009	SWCM-000500

Incorrect RF Number

TD - Engineering Fabrication Component Kit List

TD-07-010 Appendix I

Process Engineering

Component Serial No.	BMA004-0	
Kit submitted by:	Bob Jensen	3173
Fermi ID No.	315	
Date submitted:	09-Apr-07	
Need date:	11-Apr-07	
Deliver to:	IB2	
Use with Traveler No.	333844	
Job No.	408	
M&S task number:	A0601/1.02.03.02	
Drawing Title:	Booster Corrector Magnet Assembly	
Drawing No.	ME-445311	Rev None

Material Control

Parts available

Verified by:	Marsha Lamont
Fermi ID No.	4223
Date submitted to stockroom:	4/16/07

Parts issued

Issued by:	
Fermi ID No.	12698
Date issued:	4/25/07
Parts received by E&F:	Bob Jensen
Fermi ID No.	0315
Date received by E&F:	4/25/07

RECEIVED APR 16 2007 MATERIAL CONTROL/IB4

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	A/R	1C3	—	—		SP76-052200
2	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has	—	—		Mixed in IB#2
3	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has	—	—		Mixed in IB#2
4	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	~~IB#2 has~~ 22A2	4	✓	86146	~~Attached to Kit List~~
5	Terminal Block	MA	393625		ea	6	26C1	6	✓	85706	SWCM-001900 ~~SIR # Pending~~
6	Eyebolt w/shoulder	MA	393720	A	ea	4	IB#4	4	✓	86099	SWCM-002000 ~~SIR # Pending~~
7	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	~~19B7 Due 4/5~~	6	✓	86129	400 pcs.
8	Core Segment Assembly	MC	445013	C	ea	12	IB#2 has	—	—	85844/85888	SWCM-000800
9	Coil Assembly #1	ME	445210	E	ea	8	IB#2	—	—	86123	SWCM-000400
10	Coil Assembly #2	ME	445212	D	ea	2	IB#2	—	—	86124	SWCM-000500

TD - Engineering Fabrication Component Kit List

TD-07-010 Appendix I

Process Engineering

Component Serial No.	BMA005-0
Kit submitted by:	Bob Jensen 3173
Fermi ID No.	315
Date submitted:	03-Apr-07
Need date:	~~6-Apr-07~~ 11
Deliver to:	IB2
Use with Traveler No.	333844
Job No.	408
M&S task number:	A0601/1.02.03.02
Drawing Title:	Booster Corrector Magnet Assembly
Drawing No.	ME-445311 Rev None

Material Control

Parts available

Verified by:	Marsha Schaumburg
Fermi ID No.	4223
Date submitted to stockroom:	4/16/07

Parts issued

Issued by:	Duff Broussard
Fermi ID No.	12698
Date issued:	4/25/07
Parts received by E&F:	Bob Jensen
Fermi ID No.	0315
Date received by E&F:	4/26/07

RECEIVED APR 16 2007 MATERIAL CONTROL/IB4

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	A/R	1C3	—	—	—	SP76-052200
2	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has	—	—	—	Mixed in IB#2
3	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has	—	—	—	Mixed in IB#2
4	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	~~IB#2 has~~ IB4 22A2	4	✓	86146	~~Attached to Kit List~~ 150 pc, Accepted
5	Terminal Block	MA	393625		ea	6	26C1	6	✓	85706	SWCM-001900 ~~SIR # Pending~~
6	Eyebolt w/shoulder	MA	~~393720~~ 393841	A	ea	4	16A8 IB#4	4	N/A	86099	SWCM-002000 ~~SIR # Pending~~
7	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	~~Due 4/5~~ 19B7	6	✓	86129	400 pc.
8	Core Segment Assembly	MC	445013	C	ea	12	IB#2 has	—	—	85844/85888	SWCM-000800
~~9~~	~~Coil Assembly #1~~	~~ME~~	~~445210~~	~~E~~	~~ea~~	~~8~~	~~IB#2 has~~			~~86123~~	~~SWCM-000400~~
~~10~~	~~Coil Assembly #2~~	~~ME~~	~~445212~~	~~D~~	~~ea~~	~~2~~	~~IB#2 has~~			~~86124~~	~~SWCM-000500~~

Incorrect RF Number

ADDITIONAL PARTS REQUEST

Serial # BMA004/005

Date 4/26/07

Project/Task # A0601/1.02.03.02

Job Ticket # 408

PO #

Other BMA Mounting Feet Eyebolts

Requested by (include ID) B. Jensen 0315

Need by date 4/26/07

Deliver to IB#2

MMR #

Machine Shop Req #

☐ Defective Parts Issued ☐ Parts Scrapped ☐ A/R Items

☐ Defective Assembly ☐ Missing from Kit already issued

☑ Individual Parts ☐ Consumables ☐ Parts Lost

Acquisitioner Name/ID Marsha Edwards

Date 4/26/07

	Location	Part #	Rev.	QTY	UOM	Description	RF #	Spares #
150-QC 1)	IB4	MA 393481	-	8	Ea	Eyebolt w/shoulder 3/8"-16 x 1 ¼" lg	86210	
2)								
3)								
4)								
5)								
6)								
7)								
8)								
9)								
10)								

STOCKROOM SIGNATURE _____ **ID#** 2698 **DATE** 4/26/07

PARTS RECEIVED BY _____ **ID#** 0315 **DATE** 4/27/07

PARTS DELETED FROM DATABASE _____ **ID#** _____ **DATE** _____

TD - Engineering Fabrication Component Kit List

TD-07-010 Appendix I

Process Engineering

Component Serial No.	BMA006-0
Kit submitted by:	Bob Jensen 3173
Fermi ID No.	315
Date submitted:	17-Apr-07
Need date:	20-Apr-07
Deliver to:	IB2
Use with Traveler No.	333844
Job No.	408
M&S task number:	A0601/1.02.03.02
Drawing Title:	Booster Corrector Magnet Assembly
Drawing No.	ME-445311 Rev None

Material Control

Parts available

Verified by:	Marsha Schmidt
Fermi ID No.	#4223
Date submitted to stockroom:	5/11/2007

Parts issued

Issued by:	
Fermi ID No.	12693
Date issued:	5/15/07
Parts received by E&F:	
Fermi ID No.	4589
Date received by E&F:	15 MAY 2007

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	1 lb	1C3	1-LB-	✓	82767	SP76-052200
17	Fiberglas Adhesive Backed Tape	MA	225104		rl	A/R	IB#2 has				SP84-00130
2	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has				Mixed in IB#2
3	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has				Mixed in IB#2
4	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	22A2	4	✓	86146	150 pcs.
5	Terminal Block	MA	393625		ea	6	26C1	6	✓	85839	SWCM-001900
6	Eyebolt w/shoulder	MA	393841		ea	4	~~18A8~~ R7,2,2	4	✓	86210	SWCM-002000
7	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	19B7	6	✓	86129	382 pcs.
18	Pig Putty (New Pig)	MA	393829		pkg	2	IB#2 has				
8	Core Segment Assembly	MC	445013	C	ea	12	IB#2 has				SWCM-000800

TD - Engineering Fabrication Component Kit List

TD-07-010 Appendix I

Process Engineering

Component Serial No.	BMA007-0
Kit submitted by:	Bob Jensen 3173
Fermi ID No.	315
Date submitted:	17-Apr-07
Need date:	11-May-07
Deliver to:	IB2
Use with Traveler No.	333844
Job No.	408
M&S task number:	A0601/1.02.03.02
Drawing Title:	Booster Corrector Magnet Assembly
Drawing No.	ME-445311 Rev None

Material Control

Parts available

Verified by:	Marsha Schmidt
Fermi ID No.	04223N
Date submitted to stockroom:	5/11/2007

Parts issued

Issued by:	
Fermi ID No.	12698
Date issued:	5/15/07
Parts received by E&F:	
Fermi ID No.	4589
Date received by E&F:	15 MAY 2007

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	1 lb	1C3	1-LB.	✓	82767	SP76-052200
17	Fiberglas Adhesive Backed Tape	MA	225104		rl	A/R	IB#2 has				SP84-001300
2	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has				Mixed in IB#2
3	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has				Mixed in IB#2
4	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	22A2	4	✓	86146	150 pcs.
5	Terminal Block	MA	393625		ea	6	26C1	6	✓	85706	SWCM-001900
6	Eyebolt w/shoulder	MA	393841		ea	4	16A8	4	✓	86210	SWCM-002000
7	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	19B7	6	✓	86129	382 pcs.
18	Pig Putty (New Pig)	MA	393829		pkg	2	IB#2 has				
8	Core Segment Assembly	MC	445013	C	ea	12	IB#2 has				SWCM-000800

TD - Engineering Fabrication Component Kit List

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Process Engineering

Component Serial No.	BMA008-0
Kit submitted by:	Bob Jensen 3173
Fermi ID No.	315
Date submitted:	25-Apr-07
Need date:	27-Apr-07
Deliver to:	IB2
Use with Traveler No.	333844
Job No.	408
M&S task number:	A0601/1.02.03.02
Drawing Title:	Booster Corrector Magnet Assembly
Drawing No.	ME-445311 Rev None

Material Control

Parts available

Verified by:	Marsha Schmidt MS
Fermi ID No.	04223N
Date submitted to stockroom:	5/11/2007

Parts issued

Issued by:	[signature]
Fermi ID No.	12698
Date issued:	5/15/07
Parts received by E&F:	[signature]
Fermi ID No:	4569
Date received by E&F:	15 MAY 2007

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	1 lb.	1C3	1 - LB.	✓	82767	SP76-052200
17	Fiberglas Adhesive Backed Tape	MA	225104		rl	A/R	IB#2 has				SP84-00130
2	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has				Mixed in IB#2
3	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has				Mixed in IB#2
4	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	22A2	4	✓	86146	150 pcs.
5	Terminal Block	MA	393625		ea	6	26C1	6	✓	85706	SWCM-001900
6	Eyebolt w/shoulder	MA	393841		ea	4	16A8	4	✓	86210	SWCM-002000
7	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	19B7	6	✓	86129	382 pcs.
18	Pig Putty (New Pig)	MA	393829		pkg	2	IB#2 has				
8	Core Segment Assembly	MC	445013	C	ea	12	IB#2 has				SWCM-000800

TD - Engineering Fabrication Component Kit List

TD-07-010 Appendix I

Process Engineering

Component Serial No.	BMA009-0
Kit submitted by:	Bob Jensen 3173
Fermi ID No.	315
Date submitted:	25-Apr-07
Need date:	27-Apr-07
Deliver to:	IB2
Use with Traveler No.	333844
Job No.	408
M&S task number:	A0601/1.02.03.02
Drawing Title:	Booster Corrector Magnet Assembly
Drawing No.	ME-445311 Rev None

Material Control

Parts available

Verified by:	Marsha Schmidt MS
Fermi ID No.	04223N
Date submitted to stockroom:	5/14/2007

Parts issued

Issued by:	[signature]
Fermi ID No.	12698
Date issued:	5/16/07
Parts received by E&F:	[signature]
Fermi ID No.	4589
Date received by E&F:	16MAY2007

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	A/R	1C3				SP76-052200
17	Fiberglas Adhesive Backed Tape	MA	225104		rl	A/R	IB#2 has				SP84-00130
2	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has				Mixed in IB#2
3	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has				Mixed in IB#2
4	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	22A2	4	✓	8646	150 pcs.
5	Terminal Block	MA	393625		ea	6	26C1	6	✓	85706	SWCM-001900
6	Eyebolt w/shoulder	MA	393841		ea	4	R7,2,2 ~~16A8~~	4	✓	8620	SWCM-002000
7	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	19B7	6	✓	8629	382 pcs.
18	Pig Putty (New Pig)	MA	393829		pkg	2	IB#2 has				
8	Core Segment Assembly	MC	445013	C	ea	12	R1,1,5	12	✓	85996	SWCM-000800

TD - Engineering Fabrication Component Kit List

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Process Engineering

Component Serial No.	BMA010-0
Kit submitted by:	Bob Jensen 3173
Fermi ID No.	315
Date submitted:	09-May-07
Need date:	10-May-07
Deliver to:	IB2
Use with Traveler No.	333844
Job No.	408
M&S task number:	A0601/1.02.03.02
Drawing Title:	Booster Corrector Magnet Assembly
Drawing No.	ME445004 Rev None

Material Control

Parts available

Verified by:	Marsha Schmidt
Fermi ID No.	04223N
Date submitted to stockroom:	5/14/2007

Parts issued

Issued by:	
Fermi ID No.	12698
Date issued:	5/16/07
Parts received by E&F:	
Fermi ID No.	4569
Date received by E&F:	16 MAY 2007

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	A/R	1C3				SP76-052200
2	Fiberglas Adhesive Backed Tape	MA	225104		rl	2	IB4FR	2	✓	82460	SP84-001300
3	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has				Mixed in IB#2
4	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has				Mixed in IB#2
5	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	22A2	4	✓	86146	150 pcs.
6	Terminal Block	MA	393625		ea	6	26C1	6	✓	85939	SWCM-001900
7	Eyebolt w/shoulder	MA	393841		ea	4	~~R7,2,2. 16A8~~	4	✓	86210	SWCM-002000
8	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	19B7	6	✓	86129	382 pcs.
9	Pig Putty (New Pig)	MA	393829		pkg	2	IB#2 has				
10	Core Segment Assembly	MC	445013	C	ea	12	~~IB2 has APR~~				SWCM-000800

TD - Engineering Fabrication Component Kit List

Process Engineering

Component Serial No.: BMA011-0
Kit submitted by: TJ Gardner 4777
Fermi ID No.: 4569
Date submitted: 14-May-07
Need date: 16-May-07
Deliver to: IB2
Use with Traveler No.: 333844
Job No.: 408
M&S task number: A0601/1.02.03.02
Drawing Title: Booster Corrector Magnet Assembly
Drawing No.: ME445004 Rev None

Material Control

Parts available

Verified by: Marsha Schmidt
Fermi ID No.: 04223N
Date submitted to stockroom: 5/14/2007

Parts Issued

Issued by:
Fermi ID No. 126[illegible]
Date issued: 5/16/07
Parts received by E&F:
Fermi ID No. 4569
Date received by E&F: 16MAY07

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	A/R	1C3				SP76-052200
2	Fiberglas Adhesive Backed Tape	MA	225104		rl	2	IB4FR	2	✓	82960	SP84-001300
3	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has				Mixed In IB#2
4	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has				Mixed In IB#2
5	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	22A2	4	✓	86146	140 pcs.
6	Terminal Block	MA	393625		ea	6	26C1	6	✓	85939	SWCM-001900
7	Eyebolt w/shoulder	MA	393841	A	ea	4	R7,2,2	4	✓	86210	SWCM-002000
8	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	19B7	6	✓	86129	382 pcs.
9	Pig Putty (New Pig)	MA	393829		pkg	2	IB#2 has				
10	Core Segment Assembly	MC	445013	C	ea	12	R1,S1,L5	12	✓	85996	SWCM-000800
11	Coil Assembly #1	ME	445210	E	ea	8	IB4	8	✓	86275/86290	SWCM-000400
12	Coil Assembly #2	ME	445212	D	ea	2	IB4	2	✓	86276/86292	SWCM-000500
13	Coil Assembly #3	ME	445214	D	ea	2	IB4	2	✓	86277	SWCM-000600
14	Coil Spacer Block	MB	445270		ea	20	R7,S2,L1	20	✓	86166	SWCM-001000
15	Mounting Foot	MC	445308	A	ea	2	IB4	2	✓	86319	SWCM-000900
16	Coupling Cooling Tube	MA	445326		ea	12	R1,S1,L3	1		86147	
17	Coil Spacer Block w/3/8-16 Tap	MB	445[illegible]								

TD - Engineering Fabrication Component Kit List

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Process Engineering

Component Serial No.	BMA012-0
Kit submitted by:	TJ Gardner 4777
Fermi ID No.	4569
Date submitted:	14-May-07
Need date:	16-May-07
Deliver to:	IB2
Use with Traveler No.	333844
Job No.	408
M&S task number:	A0601/1.02.03.02
Drawing Title:	Booster Corrector Magnet Assembly
Drawing No.	ME445004 Rev None

Material Control

Parts available

Verified by:	Marsha Schmidt
Fermi ID No.	04223N
Date submitted to stockroom:	5/14/2007

Parts issued

Issued by:	
Fermi ID No.	12648
Date issued:	5/16/07
Parts received by E&F:	
Fermi ID No.	4569
Date received by E&F:	16 MAY 2007

	Description	Dwg Size	Number	Rev	Unit	Quantity Required	Location	Quantity Issued	E&F Verified	Routing Form Number	Spares Number / Comment
1	SilFos-15 Rod	MA	116256	B	ea	A/R	1C3				SP76-052200
2	Fiberglas Adhesive Backed Tape	MA	225104		rl	2	IB4FR	2	✓	82460	SP84-001300
3	Room Cure Epoxy	MA	274895		ea	A/R	IB#2 has				Mixed in IB#2
4	Filled Epoxy Mix	ES	331721		ea	A/R	IB#2 has				Mixed in IB#2
5	Skt Hd Cap Screw 3/8-16 x 2.50" lg SS	MA	393545		ea	4	22A2	4	✓	86146	140 pcs.
6	Terminal Block	MA	393625		ea	6	26C1	6	✓	85939	SWCM-001900
7	Eyebolt w/shoulder	MA	393841	A	ea	4	R7,2,2	4	✓	8620	SWCM-002000
8	Skt Hd Cap Screw #8-32 x 2.0 lg SS	MA	393817		ea	6	19B7	6	✓	86129	382 pcs.
9	Pig Putty (New Pig)	MA	393829		pkg	2	IB#2 has				
10	Core Segment Assembly	MC	445013	C	ea	12	R1,S1,L5	12	✓	85996	SWCM-000800

NOTE: the hole in the shaft was put there by FNAL in order to remove it from the magnet.

McMaster bolt

IB4 cabinet bolt (not a stock item)

Subject: FW: Eyebolt Letter
From: Mike Laymon <mike.laymon@mcmaster.com>
Date: Wed, 30 May 2007 07:47:49 -0500
To: Jamie Blowers <blowers@fnal.gov>

Jamie,
Sorry I had been out for a couple days.
Here is the e-mail I got from Chicago Hardware.

Mike

From: Robert Carlevato [mailto:rcarlevato@sbcglobal.net]
Sent: Friday, May 25, 2007 2:49 PM
To: Mike Laymon
Subject: Eyebolt Letter

Mike, per our conversation yesterday, this correspondence confirms that both eyebolts in question from the e-mail sent to us were manufactured by Chicago Hardware & Fixture Company of Franklin Park, Illinois. The eyebolt with "Chicago" across the top of the eye and the number "23" just above the shoulder are the old style eyebolts that were made by us. We have since replaced that style with the eyebolt that now has "Chicago USA" in more pronounced letters across the top of the eye and a different shoulder. We have been making the new style eyebolts for approximately the last ten years.
Regards,
Bob Carlevato

Bob Carlevato
Inside Sales Manager
Chicago Hardware & Fixture Company
9100 Park Lane Avenue
Franklin Park, IL 60131
Phone 847-455-6609 ext.1017
Fax 847-455-0012
e-mail: rcarlevato@sbcglobal.net
Proudly American Owned & Manufactured Since 1912
Office hours---Monday-Friday 8 am-4:30 pm ct

MEi
MATERIALS
ENGINEERING inc.

47W605 I. C. Trail
Virgil, IL 60151

630/365-9060
FAX 630/365-9138

May 29, 2007

Mr. Ted Beale
Fermi National Accelerator Laboratory
P.O. Box 500, MS 316
Wilson & Kirk Roads
Batavia, IL 60510-0500

Subject: Failure Analysis of Eyebolt, Project H001241

Introduction:

Materials Engineering, Inc., was requested to analyze an eyebolt that failed. Reportedly, the eyebolt was being manually tightened, with a screwdriver used to increase the installation torque. The zinc plated steel eyebolt contains the markings "I 3/8 Chicago USA 23". An overall view of the eyebolt received for analysis is presented in Figure 1.

Procedure:

- The hardware was examined optically at up to 60x using a stereomicroscope.
- The fracture surface was examined at higher magnification in the scanning electron microscope (SEM).
- Hardness of the sample was measured directly on the surface of the sample per ASTM E18 using Rockwell A Scale (HRC) and converted to Rockwell B Scale (HRB) per ASTM E140.
- Chemical composition was determined using optical emission spectroscopy (OES) per ASTM E415.

Results:

The eyebolt failed in the first thread, separating into two sections. The fracture surface is heavily smeared with the damage present in the rotational direction, Figure 2, consistent with having failed during tightening.

SEM examination of the fracture surface confirmed the presence of heavy damage, both on the fracture surface and on the shoulder adjacent to the threads, Figures 3 and 4. Only ductile dimples were detected on the fracture surface, Figure 5. Dimples are characteristic of a single event overload event in a ductile material. The dimples are elongated, indicating they were caused by excessive torsional shear forces, consistent

with failure during tightening. No evidence of embrittlement or materials defects was detected associated with the failure.

Chemical analysis determined the eyebolt meets the chemical composition for AISI 1030 carbon steel, Table 1. Hardness averaged 96.5 HRB. This indicates the eyebolt is of commercial quality and not a graded component that was heat treated to increase its strength.

Summary and Conclusions:

The eyebolt failed due to the application of excessive torsional loading during installation. The failure is entirely ductile, with no evidence of embrittlement or materials defects.

The eyebolt is fabricated from plain carbon steel of low hardness, and is not a heat treated graded high strength component, but of commercial quality.

The installation failure would likely not have occurred if a high strength component were used. However, the torsional overload failure of this eyebolt does not affect the inherent ability of the similar eyebolts to perform their intended function of supporting tensile loads, as long as the loads are within the values specified for this class of commercial product.

Please call if you have any questions or require additional analysis.

Bill Durako, P.E.
Principal Engineer

Table 1: Chemical Composition

Element	Eyebolt	AISI 1030
Carbon (C)	0.30	0.28-0.34
Silicon (Si)	0.20	-
Manganese (Mn)	0.75	0.60-0.90
Phosphorus (P)	0.018	0.040 max.
Sulfur (S)	0.023	0.050 max.
Chromium (Cr)	0.12	-
Molybdenum (Mo)	0.02	-
Nickel (Ni)	0.10	-
Aluminum (Al)	<0.02	-
Cobalt (Co)	<0.02	-
Copper (Cu)	0.26	-
Niobium (Nb)	<0.02	-
Titanium (Ti)	<0.02	-
Vanadium (V)	0.02	-
Iron (Fe)	balance	balance

Note: All values in Weight Percentage. Test method OES per ASTM E415.

Figure 1:
Photograph showing an overall view of the component received for analysis, on a one inch grid.

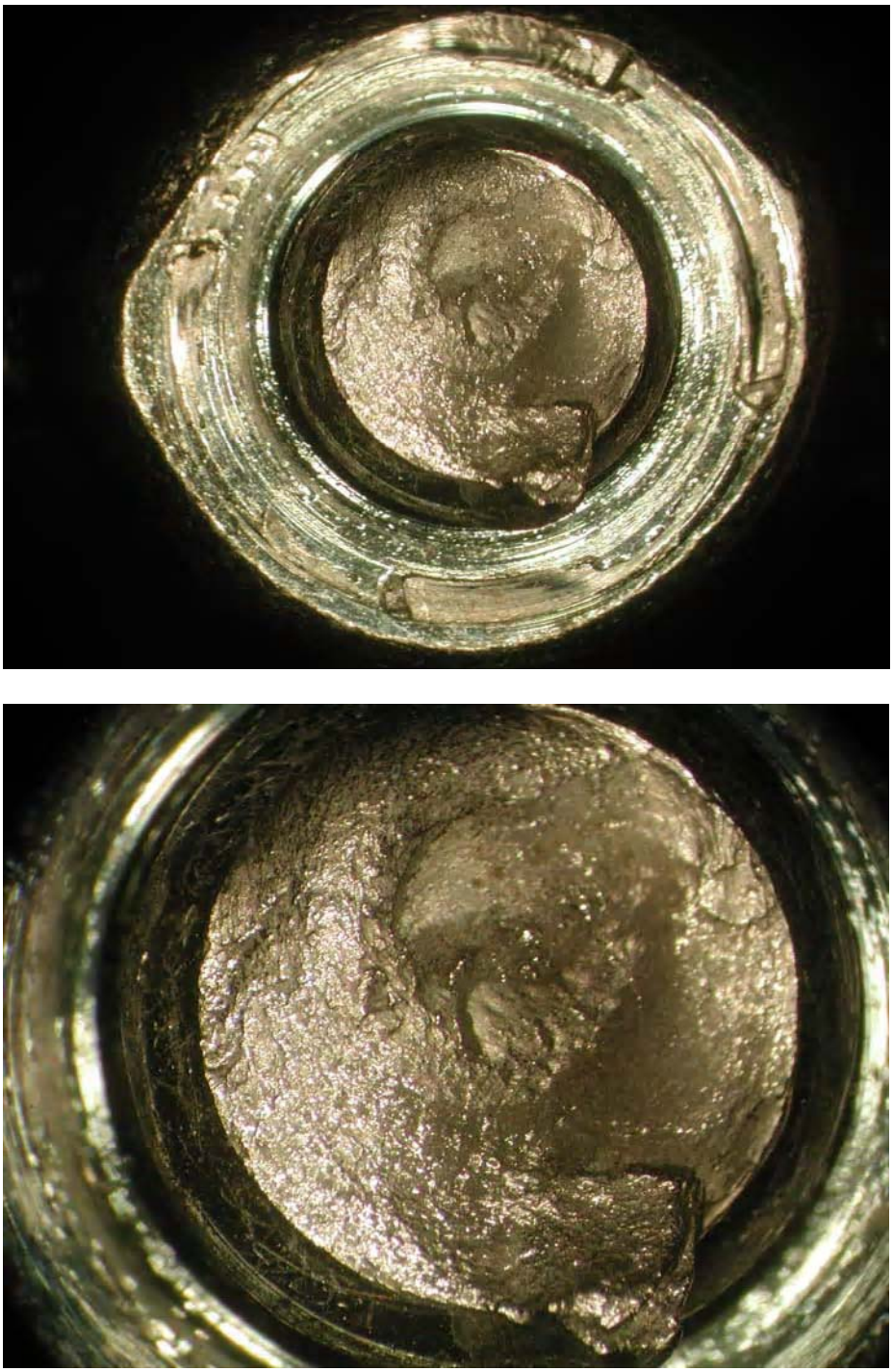


Figure 2:
Photographs showing the fracture surface and adjacent shoulder, with heavy rotational damage present.

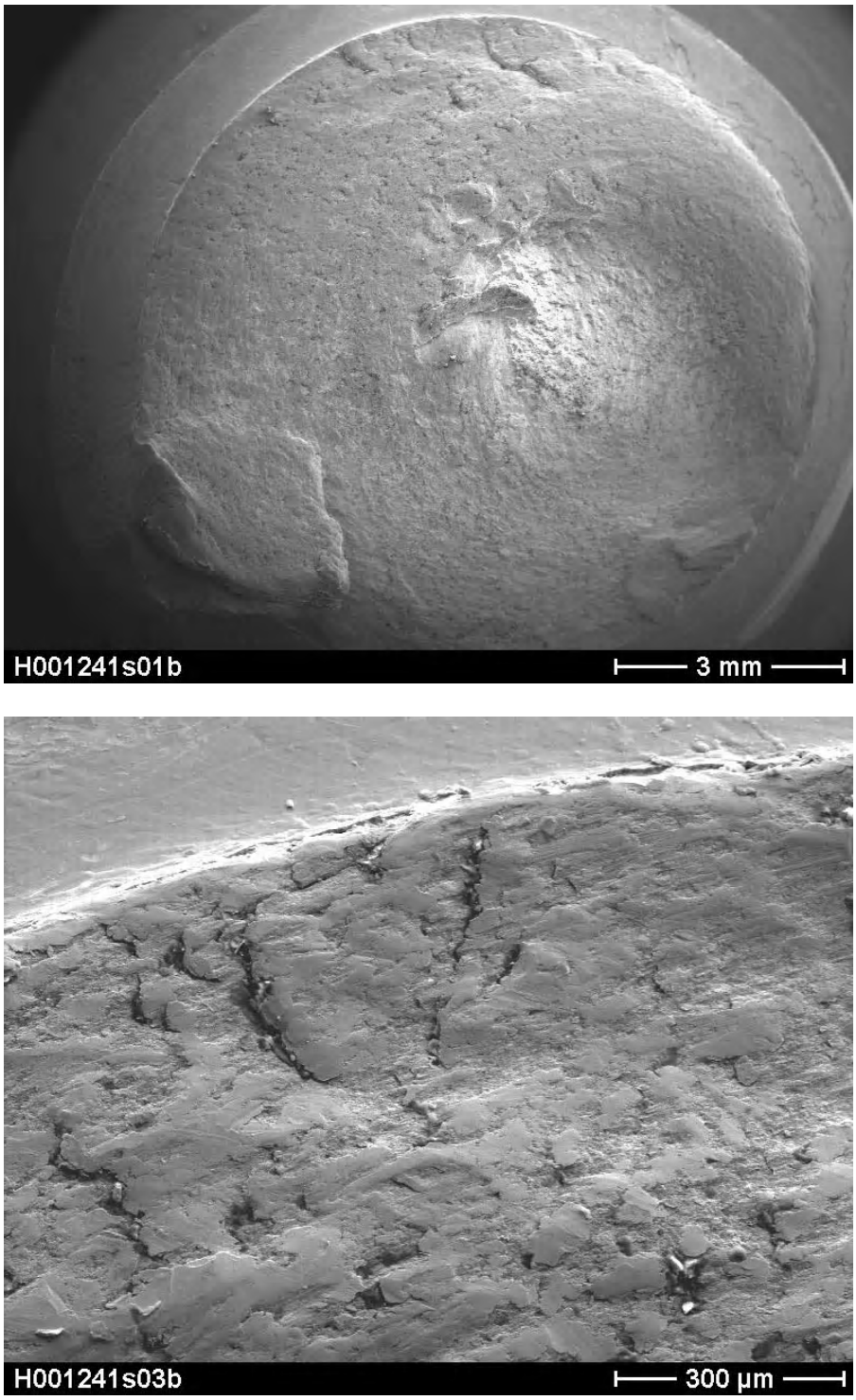


Figure 3: top ~12x, bottom ~120x
SEM photographs showing an overall view of the fracture surface (top) and a closer view of the rotational wear on the fracture surface (bottom).

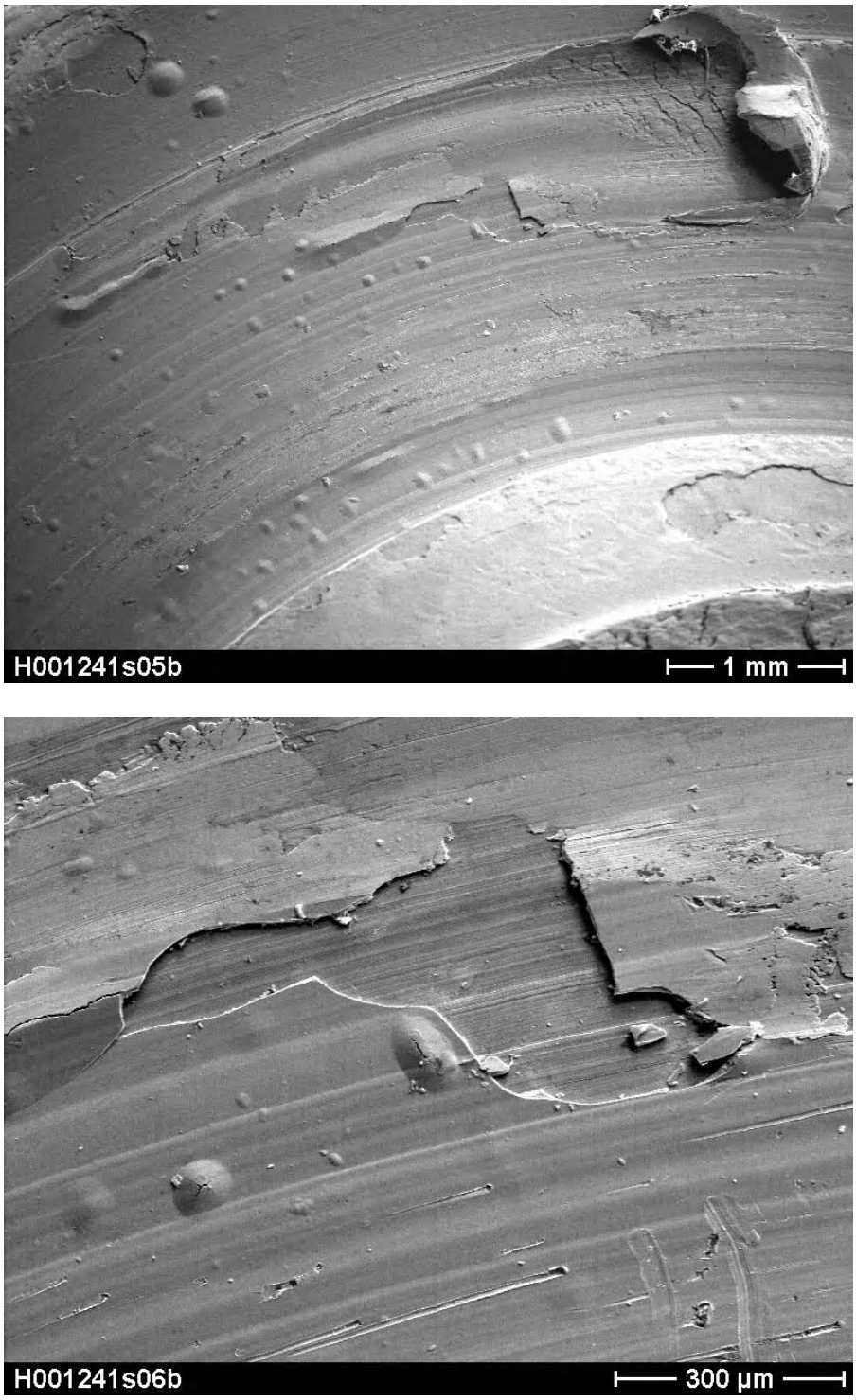


Figure 4: top ~28x, bottom ~120x
SEM photographs showing the rotational damage on the shoulder adjacent to the fracture surface, sufficient to cause flaking of the plating.

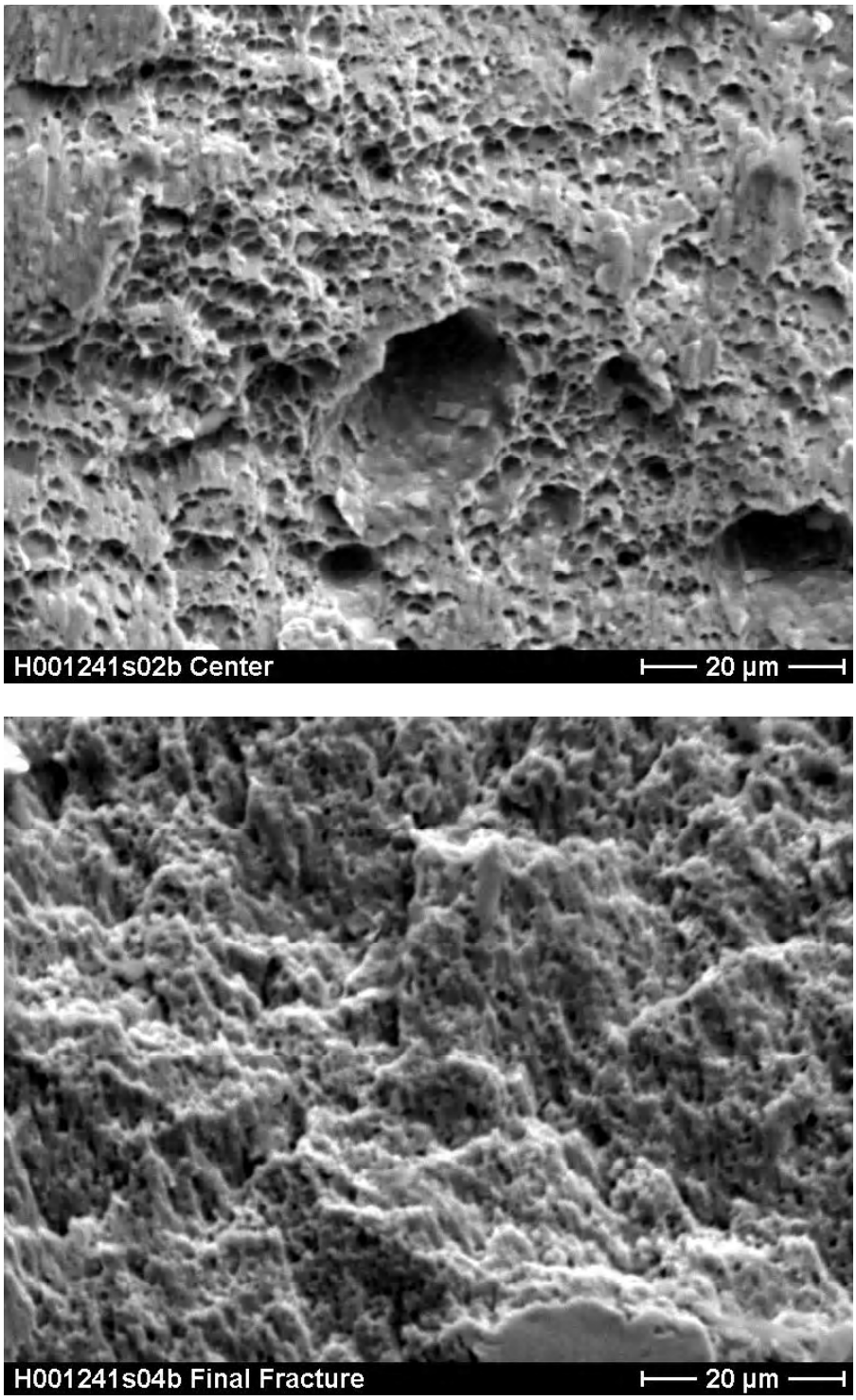


Figure 5: ~1600x
SEM photographs showing elongated dimples on the fracture surface, characteristic of torsional overload in a ductile material. No evidence of embrittlement was detected.

Materials Engineering, Inc.

Laboratory Accreditation

The American Association for Laboratory Accreditation (A2LA) has accredited Materials Engineering, Inc., for technical competence in the field of Mechanical Testing. Materials Engineering, Inc., meets the requirements of ISO/IEC 17025 "General Requirements for the Competence of Testing and Calibration Laboratories" (equivalent to relevant requirements of the ISO 9000 series of standards) as described in certificate number 1523.01. The accreditation covers specific tests and types of tests as represented on the scope of accreditation, which will be provided to customers upon request.

Clarifying Statements

1. The information provided is for the private use of our client and may not be published or reproduced in part or in total without our expressed consent.

2. The test data reported pertains only to the item(s) tested, and does not necessarily extend to the lot or batch from which the sample(s) were drawn. We accept no responsibility or liability for results due to non-representative test items, improper sampling, insufficient testing or misinformation.

3. Materials Engineering, Inc. based the findings, conclusions and opinions expressed in this report on the information provided by the customer and observations obtained at the time of inspection and preparation of this report. We reserve the right to add to, or modify this report should additional information become available.

4. Unless otherwise specified in the report, all testing is conducted by Materials Engineering, Inc.

5. If an ASTM specification is listed as a test method, the uncertainty of the measurement is included in the referenced test specification. For all other tests, contact the author of the report for an estimate of uncertainty.

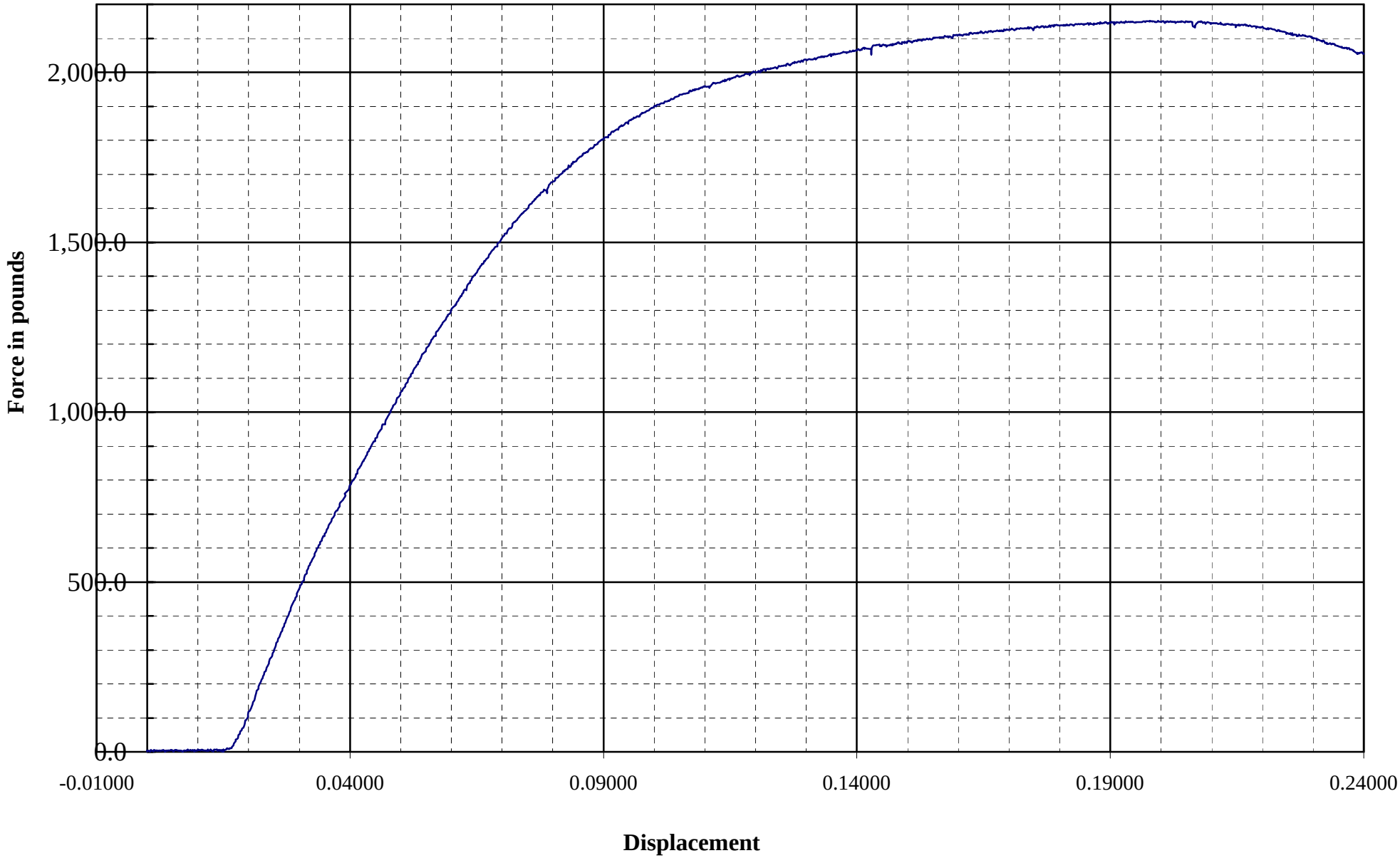
6. It is our policy to retain components, samples and remnants for 30 days from the date of the report, after which they may be discarded. Please contact us immediately if you desire your components or samples to be returned to you, or to be retained for a longer period of time.

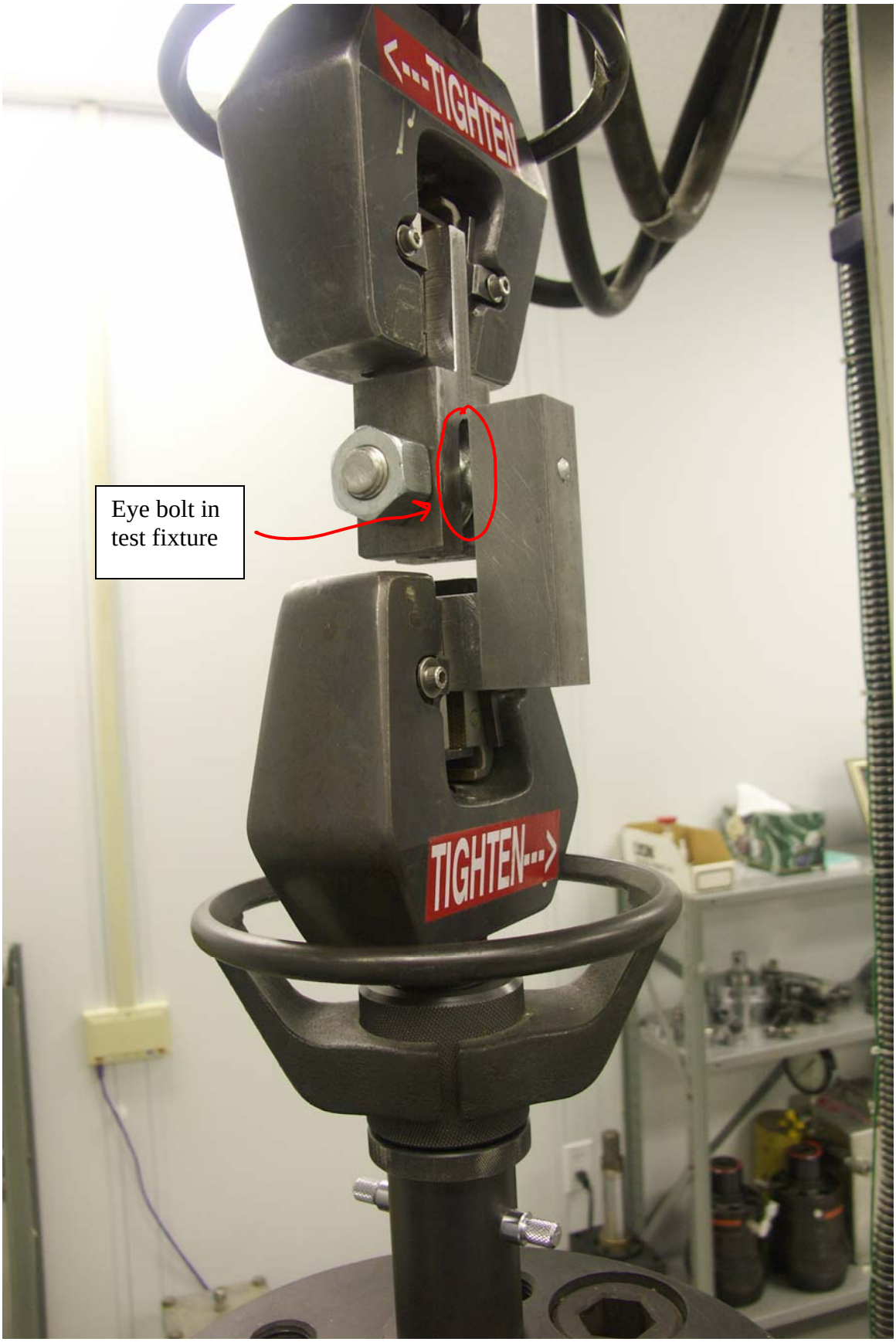
ACCREDITED
1523.01

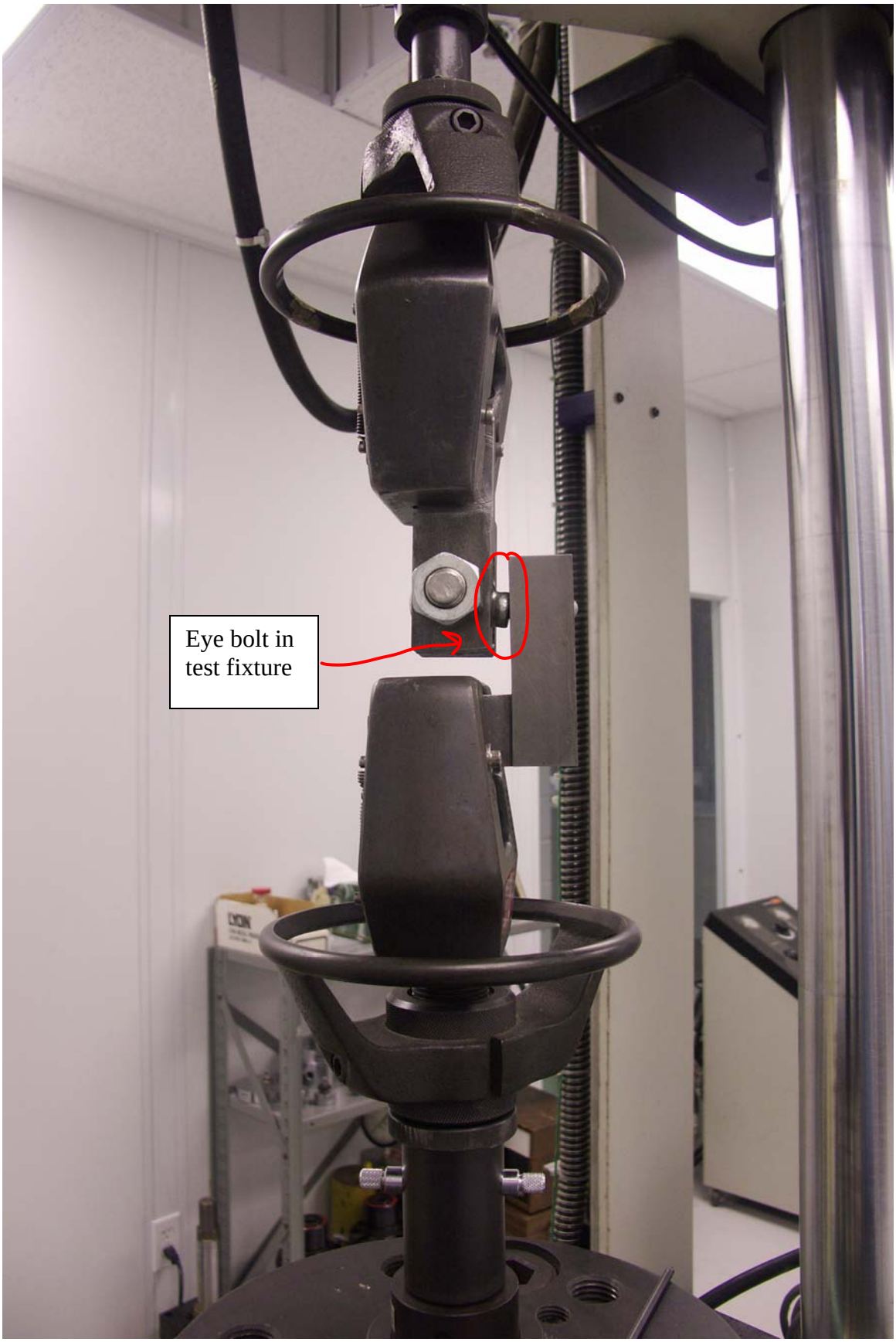
June 12, 2002

Tensile Test
BMA Eye Bolt
BMA_1

Maximum Force: 2151.7 lbf
Crosshead displacement: 0.1977 inch




<---TIGHTEN
Eye bolt in test fixture
TIGHTEN--->


Eye bolt in
test fixture

Rationale for using the bolts in the horizontal position:
The decision to use eye bolts in the horizontal position was done by analyzing the risks versus the costs. Due to geometry considerations, the only safe location to place the lifting bolts was on the feet on the bottom of the magnet. The magnets are going to be installed in high radiation areas, and sometimes it is very hard to reach these bolts. As such it is very desirable to have them installed on the magnet permanently. We will make 60 magnets for the Booster, and each magnet shall be furnished with 4 lifting eyes (total we need 240 lifting eyes).

Each swivel lifting hoist (designed to be used in such application), costs $52.50 (McMaster-Carr #2994T64), while the shoulder eye bolts are only $2.52/ea (McMaster-Carr #3014T471).

The cost difference is $11,995.20. Conservative calculations and a load test proved them to be safe for our application (see following paragraphs).

Calculations of bolts in horizontal position (e-mail dated 16-Apr-2007):
The normal grade 2 steel 3/8"-16 bolt is rated for 3,200 lbs. The shoulder diameter is 0.66", the distance from shoulder to the eye center is 1.1". That makes the eye bolt capability at 90 degrees load: 3,200x0.66"/1.1"/2=960 lbs. Of course, we need sufficient reserve in the lifting elements stress, but keeping in mind the total magnet weight is 470 lbs (with a BPM probably not more then 500 lbs), each eye bolt sees only 125 lbs (safety factor of 7.68). Besides, the eye bolts made of better then grade 2 steel with higher strength. Of course, the eye bolts shall be properly located with shims, as recommended.

Sasha Makarov

Load test and Lifting Engineer approval (e-mail dated 03-May-2007):
Taking into account that the price of 3/8"-16 x 1.25" lg shoulder pattern forged eyebolt is significantly lower than 3/8"-16 swivel hoist ring ($2.50 vs $53), you requested that there should be a waiver to use eyebolts instead swivel rings to lift these magnets.

The code does not allow the eyebolts to be used in the configuration that you plan to lift these magnets. I understand that you need ~250 of these lifting attachments. Last week, a load test was conducted at IB2 with the chosen size and material eyebolt and fiberglass support block to prove that the max stress allowed on the eyebolts is not reached during the undesired loading condition. Rich Ruthe and I then saw the actual magnet at IB1 with the eyebolt attachments.

My first proposal would be to buy some swivel rings, attach them to the lifting straps. When the straps will be used to lift the magnet, then the ring can be attached to the eyebolts. This would eliminate the undesired lifting condition. You explained that these magnets are not easily reachable in the tunnel to perform this procedure. Taking into account the apparent reasons, choice of eyebolt size and material with a high safety factor (from your calculations) and a successful load test, I recommend that you proceed with the eyebolts as planned.

Tug Arkan